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AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT X, USE OF MEASURING TOOLS IN DIESEL MAINTENANCE.

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THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF THE PRECISION MEASURING TOOLS USED IN DIESEL ENGINE MAINTENANCE. TOPICS ARE (1) LINEAR MEASURE, (2) MEASURING WITH RULES AND TAPES, (3) GETTING PRECISION WITH MICROMETERS, (4) DIAL INDICATORS, (5) TACHOMETERS, (6) TORQUE WRENCH, (7) THICKNESS (TECHER) GAGE, AND (8) VALVE REPAIR EQUIPMENT. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "USE OF MEASURING TOOLS IN DIESEL MAINTENANCE" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 865 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

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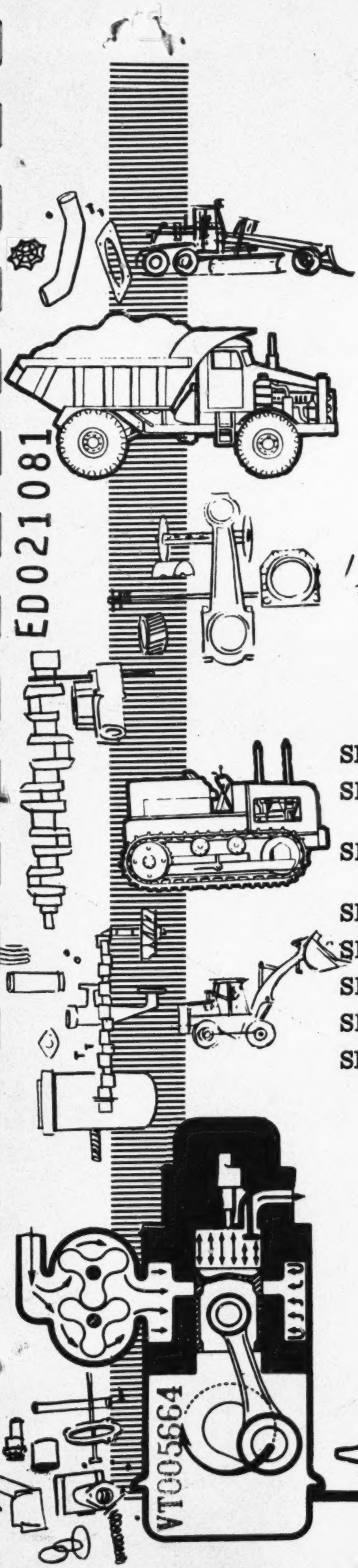
STUDY AND READING MATERIALS



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AUTOMOTIVE DIESEL 1 MAINTENANCE

USE OF MEASURING TOOLS IN DIESEL MAINTENANCE · UNIT X

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Diesel engines are precision made. Every component of the engine is machined accurately to size within very close limits. Careful measuring by the maintenance man is a MUST if he is to insure a proper fit, the correct measurement of wear limits, replacement parts identification, and satisfactory operation. This unit will outline some of the tools that help the maintenance mechanic make these measurements.

SECTION A -- LINEAR MEASURE

THE STANDARD UNIT OF MEASUREMENT for linear dimensions in the United States and many other countries is the inch. The size of the inch was determined by international agreement many years ago. All gage blocks and measuring instruments are calibrated from this standard inch.

DIVISION OF AN INCH -- In specifying most dimensions, we divide our smallest unit of measurement (the inch) into smaller parts. We can consider the inch as being made up of 16 parts of identical length, which when put together end to end would total one inch. Or, we can consider the inch as made up of 32 parts, or 64 parts, or 100 parts. Figure 1 shows how the inch can be divided into fractional dimensions.

Any part of "one" is always a fraction. If we divide "one" into eight identical parts, each part would be one-eighth of the whole and would be expressed as 1/8. In the same way, two of these eight parts would be 2/8, although we might "reduce" this common fraction to a simpler one: 1/4. Fractions with denominators the same as those seen in Figure 1 are called common fractions.

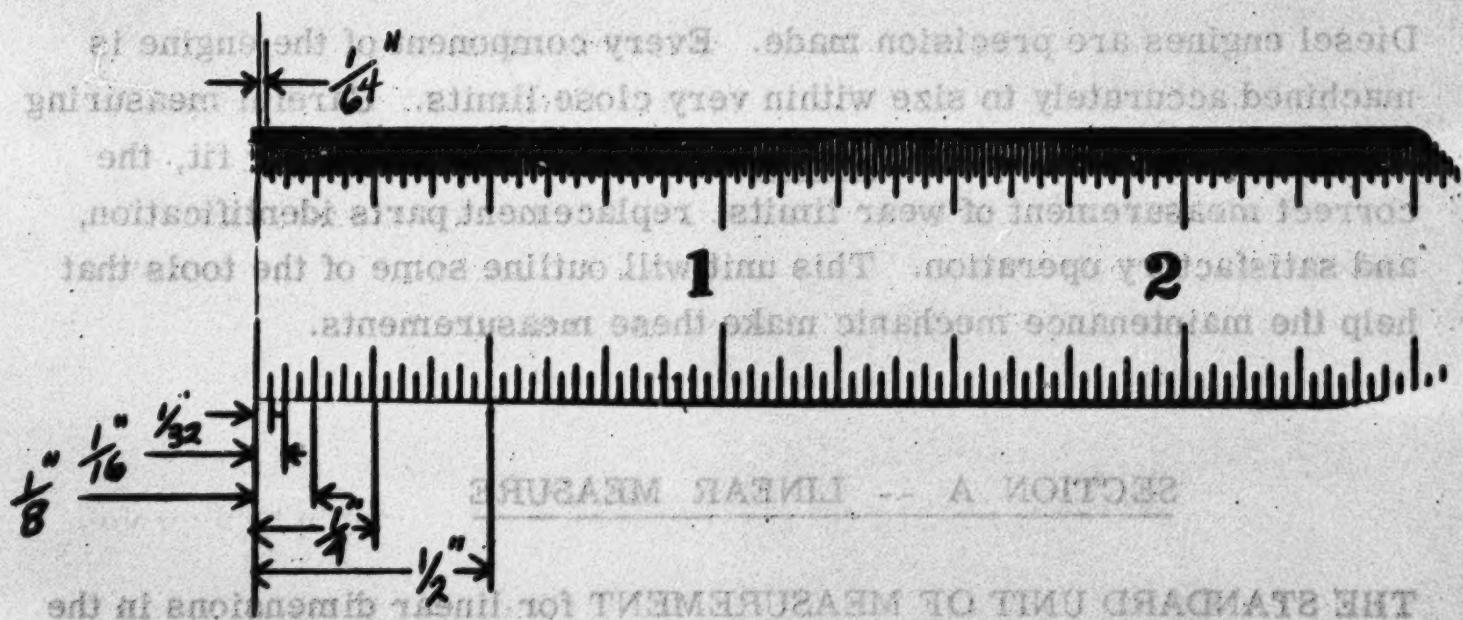


Fig. 1 Division of an inch.

The decimal system, or the system of tens as our universally used numbering system is called, can be used to express fractions of one inch. In this system, one place to the right of the decimal point indicates so many tenths of one, two places indicate so many hundredths of one, three places indicate so many thousandths of one, etc. Example:

.3 would indicate three-tenths of one.

.33 would indicate thirty-three hundredths of one.

.333 would indicate three hundred and thirty-three thousandths of one.

As we recall, fractions written in this manner are called decimal fractions.

Common fractions are most commonly used in dimensioning, but if there is need for very precise measurements, decimal fractions are used.

As we learned in our unit on fractions, every common fraction has an equivalent decimal fraction.

1/2 can be expressed as .500 (1 ÷ 2)
1/4 can be expressed as .250 (1 ÷ 4)
1/8 can be expressed as .125 (1 ÷ 8)
3/4 can be expressed as .750 (3 ÷ 4)

However, common and decimal fractions of the same value may produce different results in actual use in measurement. For example, 1/8th suggests reading the dimension to the nearest eighth on the measuring scale, whereas, .125 suggests reading the dimension to the nearest thousandth on the measuring scale. Reading the dimension to an eighth means taking a choice between 0 and 1/8th or between 1/8th and 2/8ths. Reading a thousandth means discriminating between .124 and .125 or between .125 and .126, depending on whether the true dimension is under or over one-eighth. We can see that this will make a very great difference in the accuracy of the dimension.

SECTION B -- MEASURING WITH RULES AND TAPES

THE MECHANIC'S STEEL SCALE OR RULE probably is the most frequently used of all measuring tools. It is made of a strip of high grade steel accurately divided into inches and fractions of an inch. The overall length of the scale may be 6, 9, or 12 inches, or any length that is convenient for the type of work being performed. For many ordinary uses, a 6 inch flexible steel scale is most practical.

The most common type of rule is graduated on one side to show divisions of the inch into 8ths along one edge, into 16ths along the opposite edge, and on the reverse side into 32nds and 64ths. Another type of rule coming into greater use is graduated on one side to show divisions of the inch by 16ths and 32nds, and on the reverse side by 64ths and 100ths. This makes it possible to get rough decimal readings directly without running the risk of making errors in converting fractions into decimals

or decimals into fractions. Figure 2 shows the many variations of the steel rule.

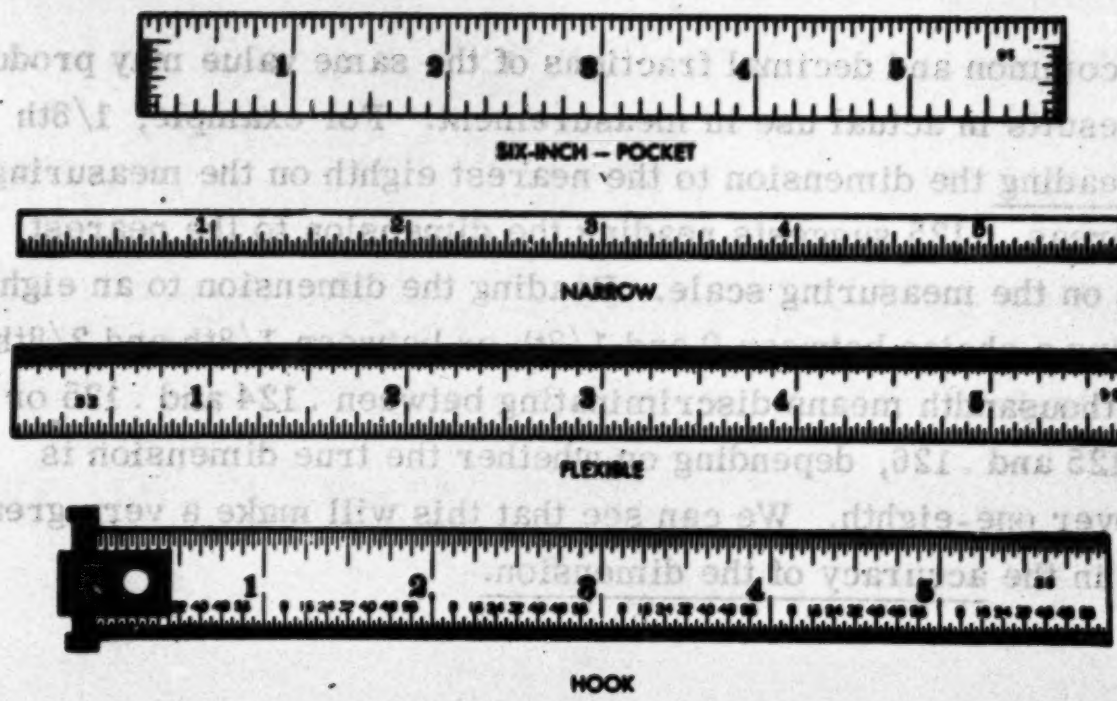


Fig. 2 Types of steel rules.

The rule is made with a high degree of accuracy, but using it as a screw driver or a scraper will quickly wear away the ends and destroy its accuracy. Even though we use the scale properly, its ends will become slightly worn, so that the end divisions cannot be depended upon for close measurements. For this reason, we will see many mechanics using only the inner inch graduations, Figure 3, when taking a measurement. Caution: If you use an inner graduation when measuring, be sure to subtract for the part of the scale not used.

If the rule is in good condition, however, and is known to be accurate, the method shown in Figure 4 may be used. Both the scale and the piece being measured are butted against a flat surface, which assures us that the ends are even.

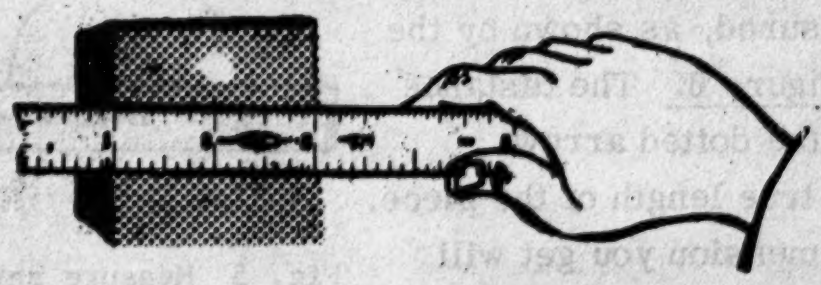


Fig. 3 Use only inner graduation on scale with worn edges.

Certain other precautions should be taken when taking measurements with a rule. When measuring inside or outside diameters, measure across the exact center of the circle, as shown in Figure 5. (The greatest dimension you get will be the true diameter).

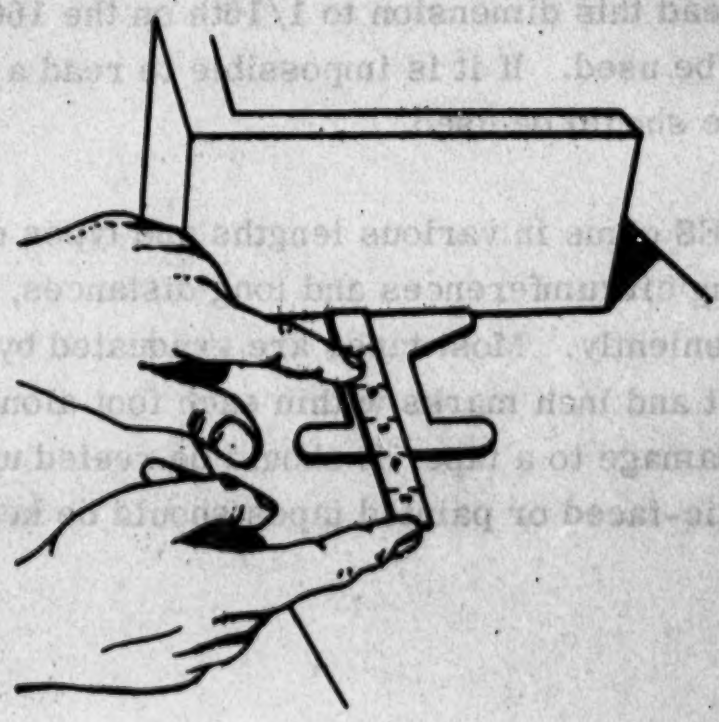


Fig. 4 Butt scale and piece against flat surface to make sure ends of each are even.

When measuring the length of a piece be sure the scale is parallel with the length to be measured, as shown by the solid arrow in Figure 6. The distance measured along the dotted arrow would not be the true length of the piece. (The smallest dimension you get will mean your scale is parallel to the length being measured.)

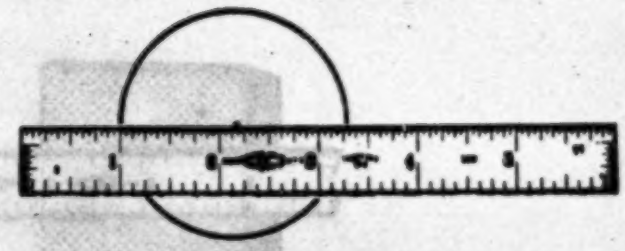


Fig. 5 Measure across center to get true diameter.

When using a rule to check a dimension, the proper graduated scale would be used to control the reading of the dimension, see Figure 7 (a). If the work being measured lines up between two graduations on the scale, as shown in Figure 7 (b) and (c), and it is not possible to read this dimension to 1/16th on the 16th scale, the 32nd scale should be used. If it is impossible to read a dimension to 1/32nd, the 64th scale should be used.

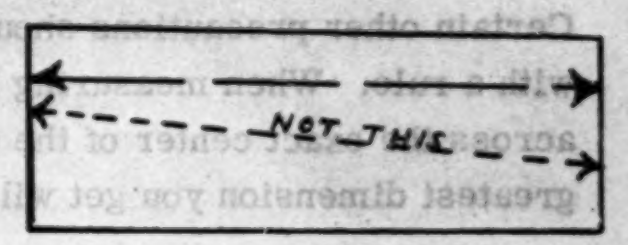


Fig. 6 Always measure parallel with length measured.

STEEL TAPES come in various lengths and types of faces. They are used for measuring circumferences and long distances, where rules cannot be applied conveniently. Most tapes are graduated by sixteenths of an inch, and show feet and inch marks within each foot along the length of the tape. To prevent damage to a tape, it should be reeled up after every measurement. Plastic-faced or painted tapes should be kept away from high heat.

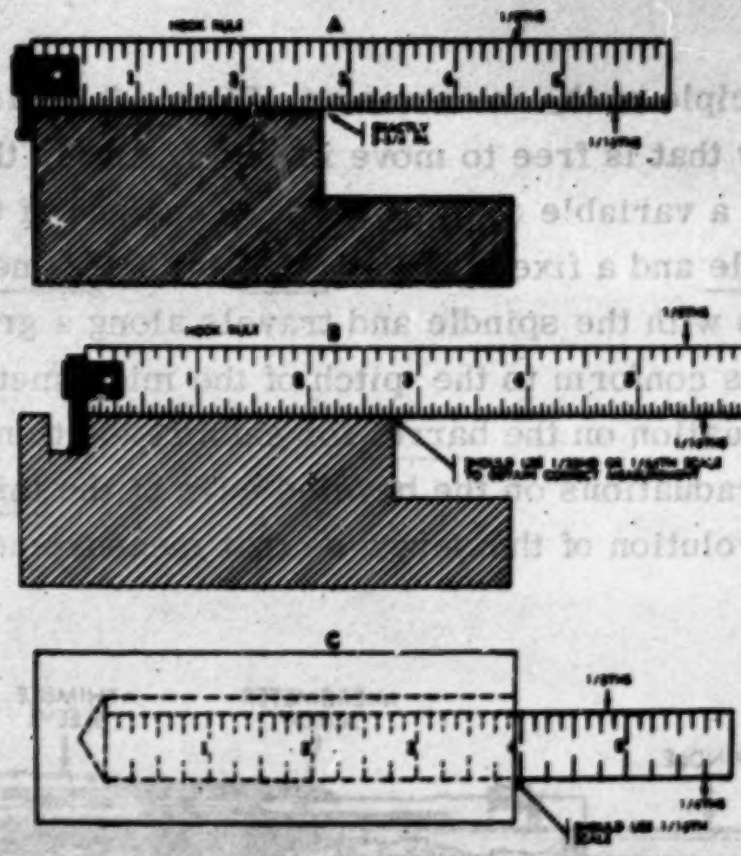


Fig. 7 Determining proper graduated scale.

SECTION C -- GETTING PRECISION WITH MICROMETERS

MICROMETERS (micrometer calipers) are used for measurements requiring precise accuracy. They are more accurate and reliable than the rules previously discussed. When the measurement has to be "right on the nose" the maintenance man will reach for the micrometer or "mic", as it is commonly called.

Micrometers are made for measuring different kinds of work. Outside micrometers are used to measure the outside diameters of round objects and the widths and thickness of flat pieces. Inside micrometers are used to measure the diameters of holes and widths of recesses and slots. Depth micrometers are used to measure the depths of holes, grooves, and slots. Screw thread micrometers are used to measure outside diameters of screw threads.

The basic principle of the micrometer, Figure 8, is found in a very accurate screw that is free to move in an accurately threaded fixed nut which provides a variable opening between one end of the micrometer screw or spindle and a fixed face or anvil in the frame. A graduated thimble rotates with the spindle and travels along a graduated barrel. The graduations conform to the pitch of the micrometer screw; hence, there is a graduation on the barrel for each revolution of the micrometer screw. The graduations on the beveled edge of the thimble accurately divide each revolution of the screw so that measurements can be made in .001".

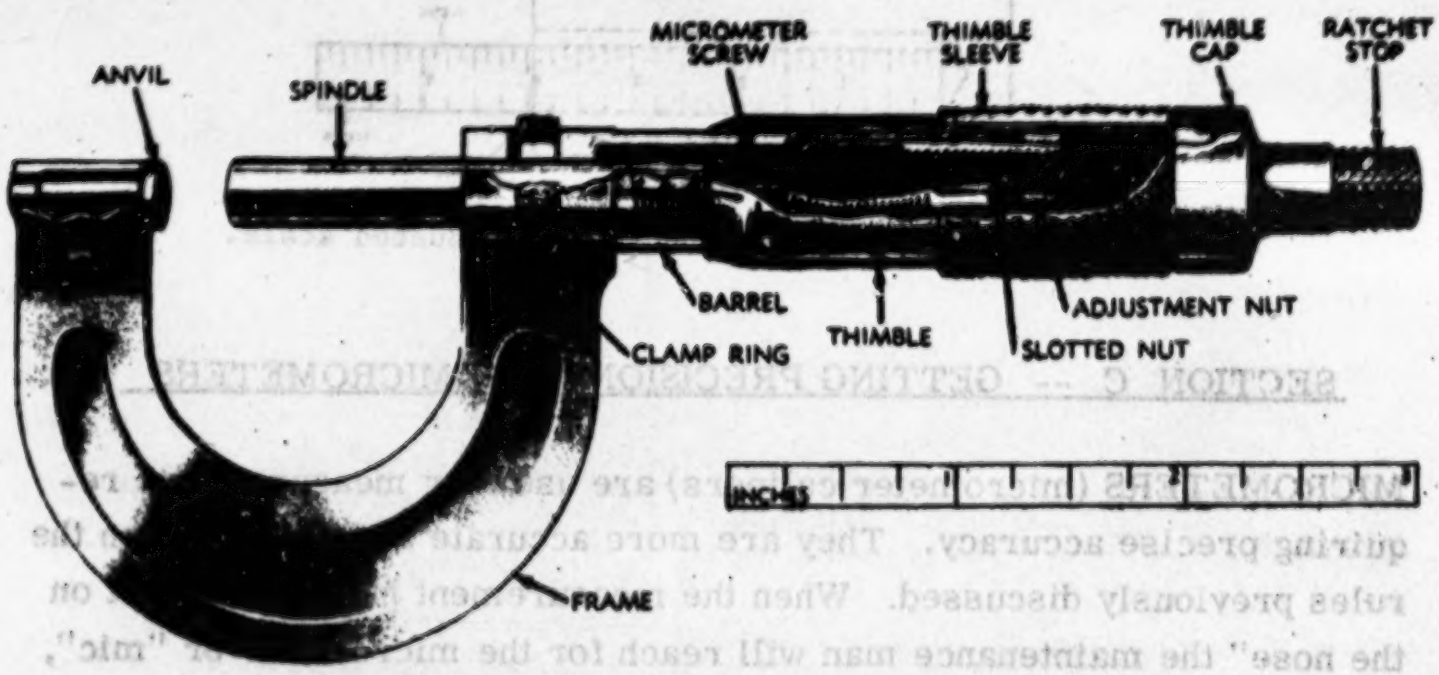


Fig. 8 Micrometer caliper -- cutaway view.

The ratchet stop furnished on some micrometers provides the proper pressure at the measuring point against the work to be measured. By turning the knurled knob slowly, a couple of "clicks" for each measurement, the needed pressure is contained, without forcing the spindle against the work. The clamp ring is a convenience for keeping the micrometer at a particular setting. A slight rotation of the knurled ring locks the spindle. Never tighten the clamp ring when the spindle is withdrawn as this might damage the clamping mechanism.

READING A MICROMETER is only a matter of reading the micrometer scale, or counting the revolutions of the thimble and adding to this any fractions of a revolution. The micrometer screw has 40 threads per inch. This means that one complete and exact revolution of the micrometer screw moves the spindle away from or toward the anvil exactly 0. 025 inch. The lines on the barrel, Figure 9, conform to the pitch of the micrometer screw, each line indicating 0. 025 inch, and each fourth line being numbered 1, 2, 3, and so fourth. The beveled edge of the thimble is graduated into 25 parts, each line indicating 0. 001 inch, 1/25 of the 0. 025 inch covered by one complete and exact revolution of the thimble. Every fifth line on the thimble is numbered to read a measurement in thousandths of an inch. Read measurement shown in Figure 9 as indicated in (1) through (4) below.

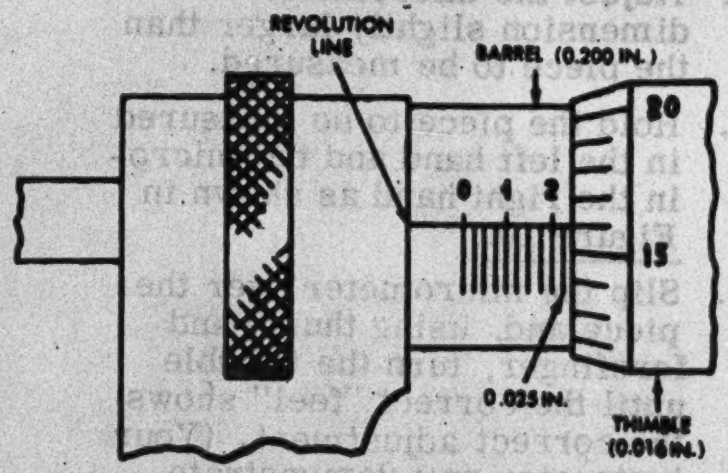


Fig. 9 Reading standard micrometer scale.

(1)	Highest figure visible on barrel.....2	=0.200 in.
(2)	Number of lines visible between No. 2 and thimble edge.....1	=0.025 in.
(3)	The line on thimble that coincides with or has passed the revolution or long line in the barrel.....16	=0.016 in.
(4)	Measurement reading.....TOTAL	=0.241 in.

USING AN OUTSIDE MICROMETER - Standard size outside micrometers measure from zero to one inch, one to two inches, two to three inches, and so on up to 23 to 24 inches. Even larger ones are available.

Small micrometers are held and manipulated with one hand when measuring small work that can be picked up. The steps are as follows:

1. Adjust the micrometer to a dimension slightly larger than the piece to be measured.
2. Hold the piece to be measured in the left hand and the micro- in the right hand as shown in Figure 10.
3. Slip the micrometer over the piece and, using thumb and forefinger, turn the thimble until the correct "feel" shows the correct adjustment. (Your instructor will demonstrate "feel". Slide the mic slightly to feel if it is too loose or too tight.)
4. Remove your fingers from the thimble and slide the mic off the piece (If the piece is not flat, do not slide the mic off.)
5. Read the micrometer as explained previously.

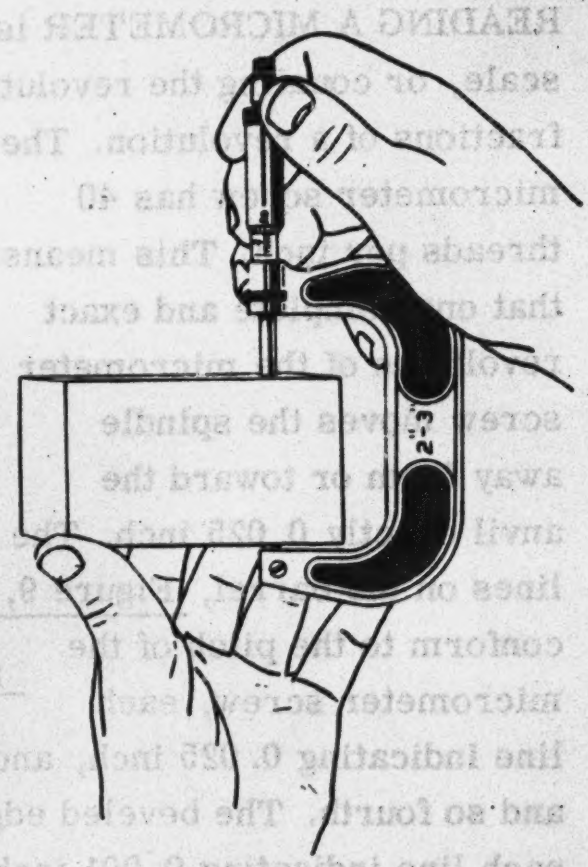


Fig. 10 Holding micrometer to measure work held in hand.

Work that connot be held in the hand,or is too large to be measured with small size micrometers, may be measured by holding the micrometer with both hands as shown in Figure 11. The frame of the micrometer is held in the left hand and the sleeve turned with the right hand.

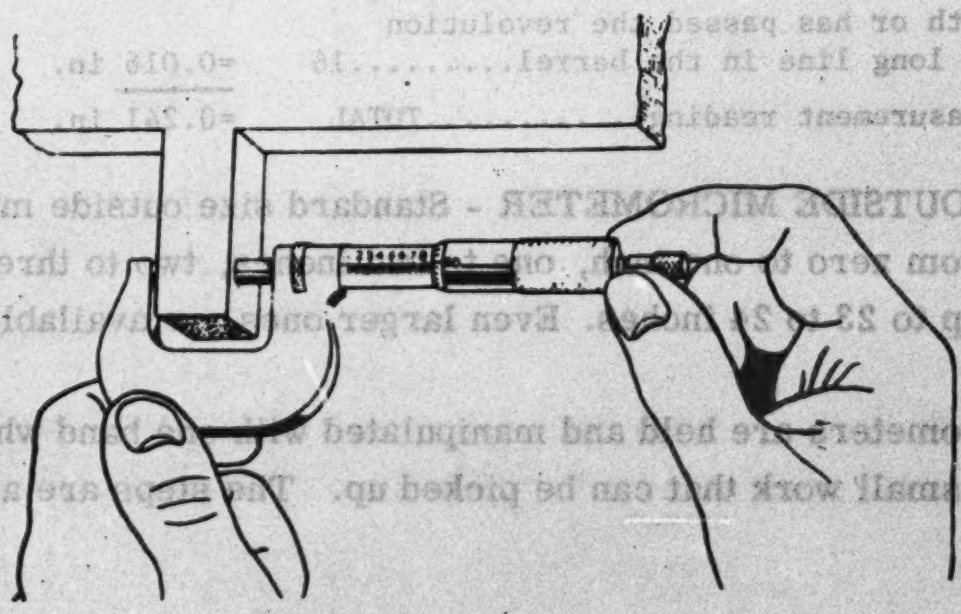


Fig. 11 Holding micrometer to measure work NOT held in the hand.

USING AN INSIDE MIRCOMETER -- In principle, the inside micrometer is exactly the same as an outside micrometer. The method of reading it is also the same.

Inside micrometers usually come in a set with one body and several extension rods of different lengths. The smaller micrometers (2 to 5 inches) have a 1/2 inch screw, therefore, the rods in this set will measure in half inch increments, i. e., 2 to 2 1/2 inch, 2 1/2 to 3 inch, etc. The larger micrometers (over 5 inches) have a one-inch screw with rod lengths that will measure in one inch increments. The steps for using the inside micrometer are as follows:

1. Set the mic to a length smaller than the dimension to be measured.
2. Place one end at some convenient place on the hole or against the slot.
3. Hold the mic body with the left hand and adjust the thimble with the right.
4. Rock the mic so the point on the thimble swings in arcs in different directions, as shown in Figure 12. This action tells you that the mic is spanning the true diameter of the hole.
5. While rocking the mic continue to turn the thimble until contact is made by both ends of the mic at the largest dimension.
6. Carefully lock and remove the mic.

DEPTH MICROMETERS -- The mic depth gage, Figure 13, is an instrument for measuring the depth of blind holes and slots. The mic shown has a screw movement of one inch and a range of from 0 to 3 inches in thousandths of an inch. These size ranges are obtained by using extension rods. (Three rods and the head make up the standard set; other rods are available for larger dimensions.) The rods are easily inserted in the head by unscrewing the cap at the end of the thimble.

Notice that the graduations on the barrel of the micrometer read from right to left, and the graduations on the thimble read from top to bottom. This is necessary because the reading, or depth, becomes greater as the rod is extended into the hole or slot. This reverse of the scale must be remembered when using the depth mic. Always remember this when reading a depth mic -- you read what you don't see and you read it backwards.

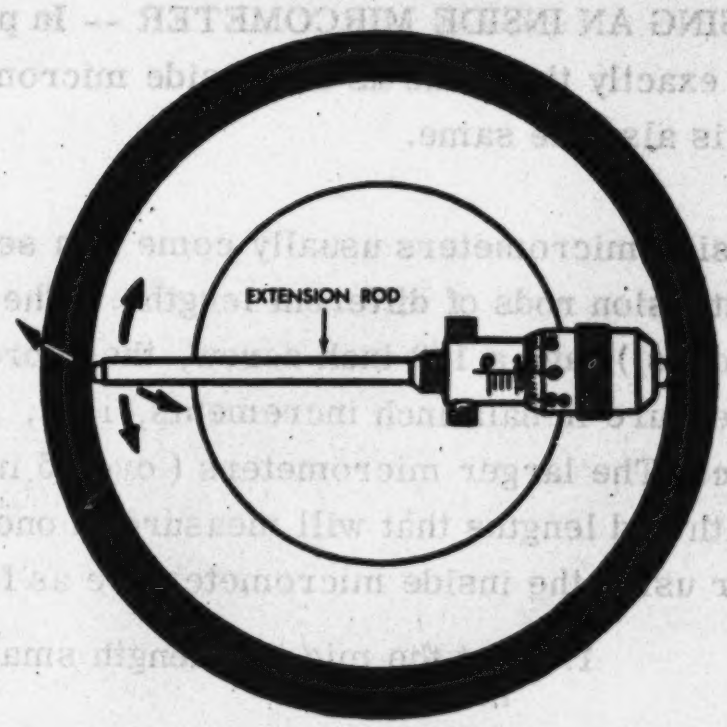


Fig. 12 Using inside micrometer with extension rod.

In Figure 14 (1) the depth micrometer shows a reading of .668. The number 6 is concealed by the thimble. There are two full spaces between the number 6 on the barrel and the beveled end of the thimble. Thus far, we have a reading of .650. To this we add the .018 seen on the thimble, to give us a total reading of .668.

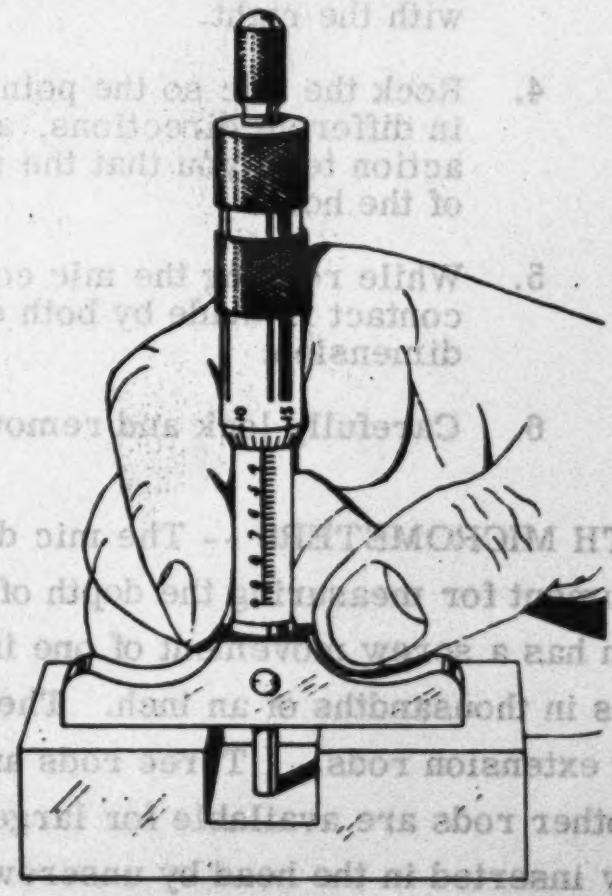


Fig. 13 Measuring with depth micrometer.

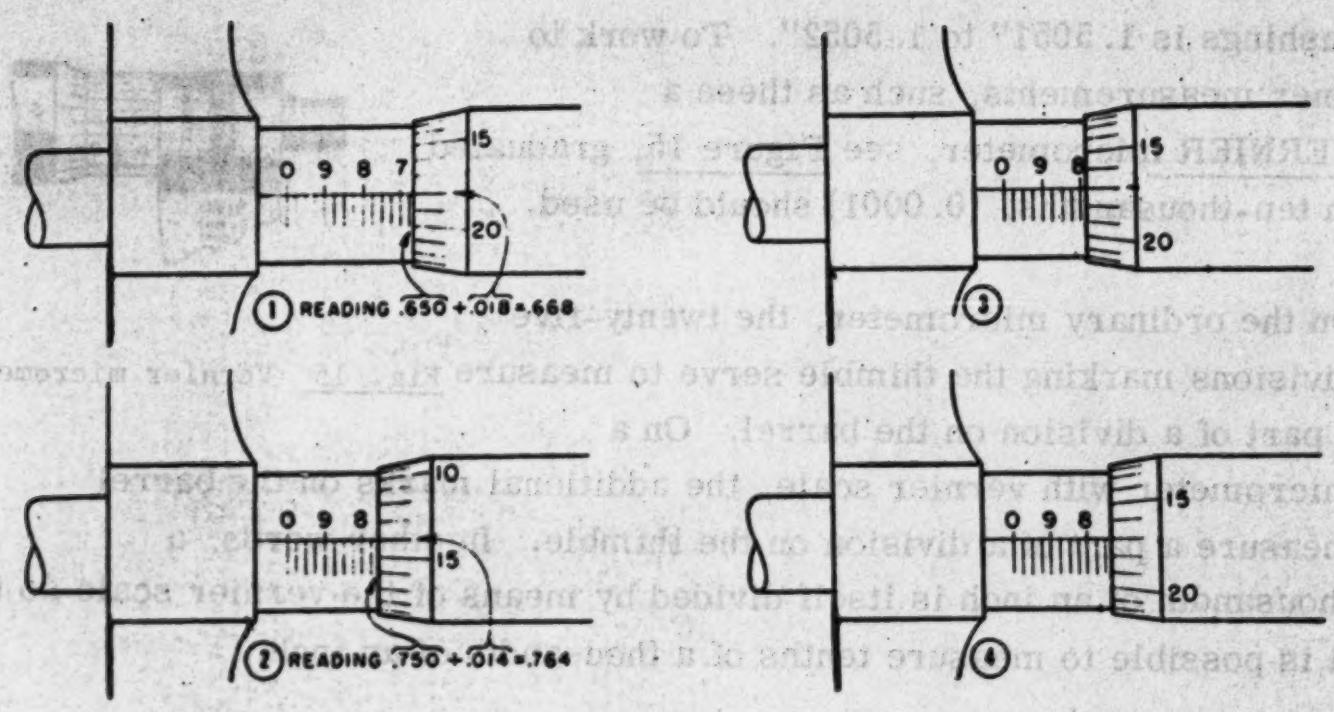


Fig. 14 Readings on depth micrometer.

Figure 14 (3 & 4) show two different readings for measurements taken with the micrometer depth gage. Reading 3 was taken with a two to three inch extension rod. We add two inches to this reading. Reading 4 was taken with a five to six inch extension rod. What are the readings of these two measurements.

Follow these steps when using a depth micrometer: First, insert the proper extension rod in the micrometer head. Second, place the gage over the hole or slot. Next, while you hold the base of the mic firmly on the workpiece with your left hand, screw the thimble down with your right hand. Finally, when the rod touches the bottom of the hole or slot, read the micrometer. Remember to add the length of the rod.

VERNIER MICROMETERS -- The standard micrometer discussed up to now is used to take measurements to the nearest one-thousandth part of an inch. This is a very accurate unit of measurement, but in diesel maintenance it is not uncommon to require tools that read to ten-thousandths of an inch. For instance, the inside diameter of the connecting rod

bushings is 1.5051" to 1.5052". To work to finer measurements, such as these a VERNIER micrometer, see Figure 15, graduated in ten-thousandths, (0.0001) should be used.

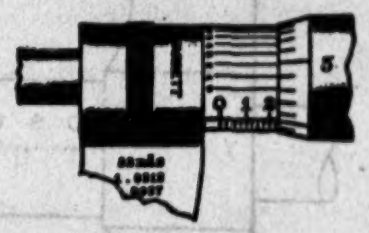


Fig. 15 Vernier micrometer.

On the ordinary micrometer, the twenty-five divisions marking the thimble serve to measure a part of a division on the barrel. On a micrometer with vernier scale, the additional marks on the barrel measure a part of a division on the thimble. In other words, a thousandth of an inch is itself divided by means of the vernier scale so that it is possible to measure tenths of a thousandth of an inch.

The vernier itself consists of ten divisions which equal, in over-all space, nine divisions on the thimble. These ten equally spaced lines are etched on the barrell; see Figure 16.

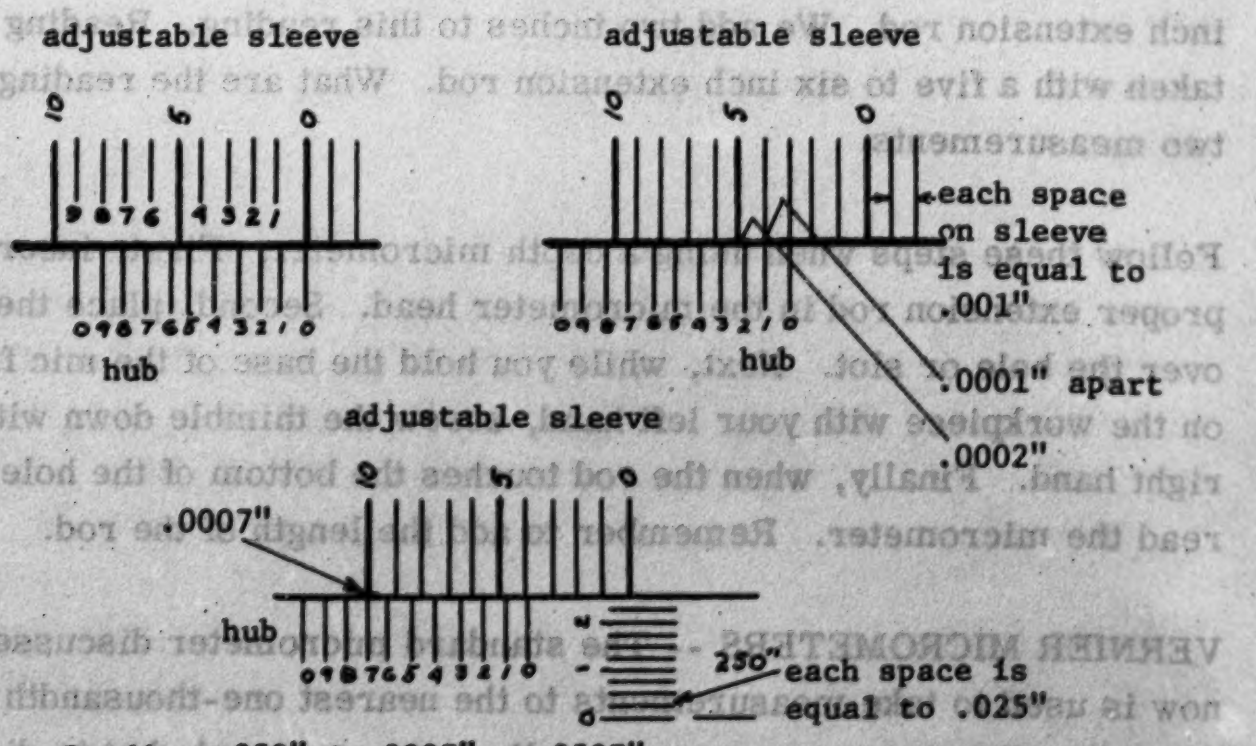


Fig. 16 Reading for three different settings of the vernier micrometer.

The first nine lines are numbered from 0 to 9, the tenth division being marked with another 0. One division is equal to 1/10 x .009 inch, or .0009 inch. The difference between the thimble and the vernier division is .0010" - .0009" = .0001".

A good deal of practice is required before a man can obtain the "feel" for reading a vernier mic, or any precision instrument for that matter. However, once a man learns the basic rules of precision instruments and uses them a few times, he can become an expert in their use.

CARE OF MICROMETERS -- Micrometers are fine instruments, and should be handled like watches. Dropping them on the floor or bench may damage their fine parts and make them useless. Keep them clean, and away from dust, grit, and grease.

Never try to measure a piece with a micrometer when the piece is in motion in a machine. This is dangerous to you and can damage both the mic and piece.

Never force micrometers into position and never use them as "C" clamps. Always open them before removing them from a piece you have measured.

SECTION D -- DIAL INDICATORS

The dial indicator, see Figure 17, is a precision measuring instrument which is used to check size variations of a machined part from the desired dimension. It has many applications in diesel maintenance work. Figure 18 shows the checking of the relative concentricity of a valve seat insert in relation to the valve guide.

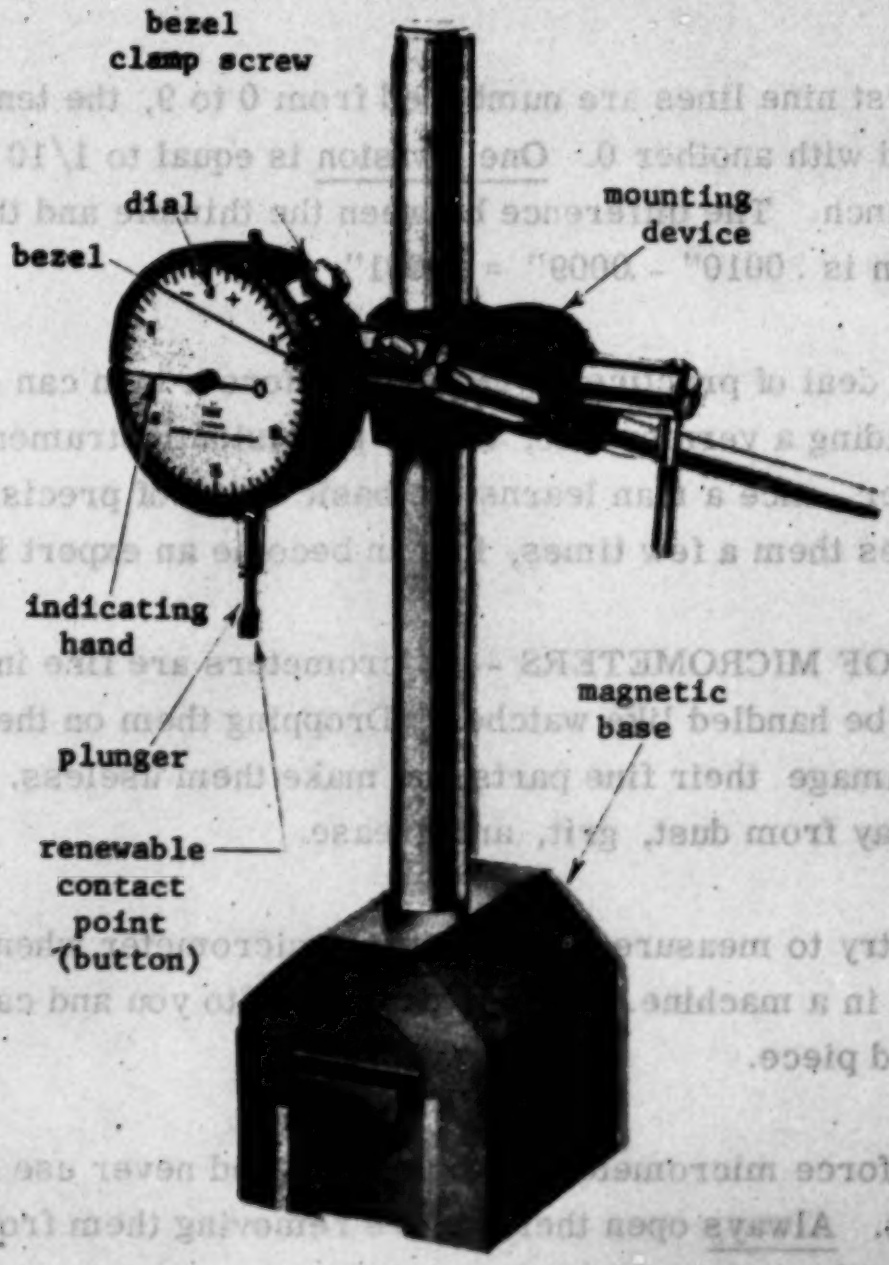


Fig. 17 The dial indicator.

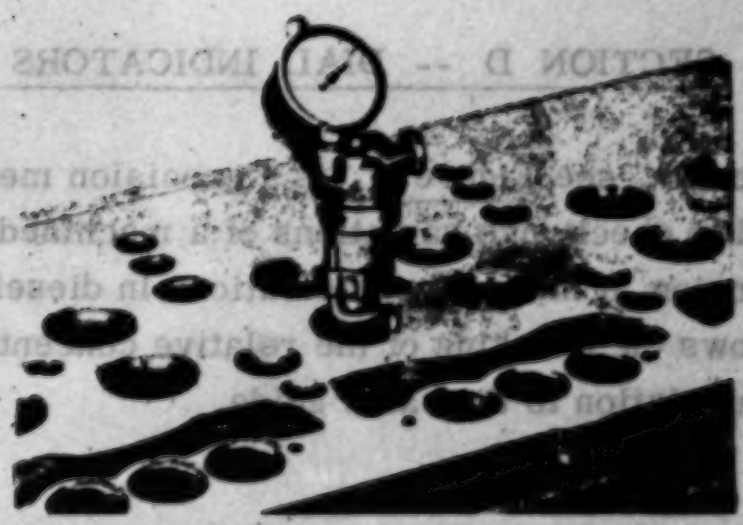


Fig. 18 Using the dial indicator.

Dial indicators range in size from about one inch to four and one-half inches in diameter. Each important part is illustrated in Figure 17. Dial indicators are usually classified as either 1/1, 000 indicators or 1/10, 000 indicators. This is marked on the dial face, just below the hand, as shown in Figure 17. The dial may be of the balanced type, in which the figures read both to the left or to the right of the zero; or it may be of the continuous reading type, in which the figures read from the zero only in the clockwise direction.

The dial is marked off (graduated) so that each graduation (space between two adjacent lines) represents a definite movement of the plunger, which is designed so that it will slide in and out. On 1/1, 000-type indicators, each graudation may represent a plunger movement of one-thousandth, one-half thousandth, or one-quarter thousandth of an inch. On 1/10, 000 indicators each graduation may represent a plunger movement of one-ten-thousandth, one-half of one-ten-thousandth, or as small as one-quarter of one-ten-thousandth of an inch.

READING THE DIAL INDICATOR -- The value of the graduations on an indicator dial is easily determined. Using Figure 17 again, we first look at the figure on the dial face, just below the center of the hand, which identifies the indicator as a 1/1, 000 type. Then,we count the number of spaces between the zero and the first numeral to the right of the zero. The first numeral is a 5, indicating . 005 of an inch (5/1, 000") of plunger travel. Since there are ten spaces bewteen the zero and the 5, the value of each graduation is equal to one-half of one thousandth of an inch.

Since it is obvious that such small movements of the plunger could not be seen, the plunger is linked to the indicator hand or pointer through a train of small gears (or through a set of linking levers) which multiply any small movement of the plunger into a larger, more easily seen movement of the indicator hand. For this reason, it can be under-

stood that the dial indicator must be mounted rigidly to some support such as shown in Figure 17, so that only the plunger can move. Any movement of the indicator body, in relation to the plunger, would cause an error in the reading.

When not in use, the plunger spring will naturally push the plunger outward, away from the indicator body, to the limit of plunger travel. On most standard indicators, the pointer will come to rest in the position occupied in Figure 17. From this position, the hand could travel only to the right, or clockwise. To use the indicator properly, the gage must be set up so that the plunger is free to travel to the right or to the left of the zero (plus or minus). When using the indicator, remember that as the plunger moves in toward the indicator body, the pointer moves clockwise, and as the plunger moves out away from the indicator body, the pointer moves counterclockwise.

Remember, dial indicator instruments are delicate; handle them carefully, and return them to their proper storage place when not in use.

USE OF DIAL INDICATOR -- The dial indicator can be used for detecting differences in the size of various parts of a work piece. For example, suppose we have a 6 inch long shaft of 3/4 inch diameter which we wish to check for concentricity of roundness, and also for taper. To check for concentricity, the set-up as shown in Figure 19 is suggested. The V-block clamp screws would be adjusted just enough to permit you to rotate the end of the shaft by hand as it rests in the blocks. The spindle lock screw of the pedestal is loosened, so that you can position the indicator at the proper height. This can be determined by watching the pointer of the indicator. The button of the indicator is brought to bear on the work piece between the V-blocks until the pointer moves clockwise . 015, at which point you lock the indicator to the spindle of the pedestal by turning the spindle lockscrew. Now the bezel clamp is loosened and the bezel ring is turned until the zero on the face of the

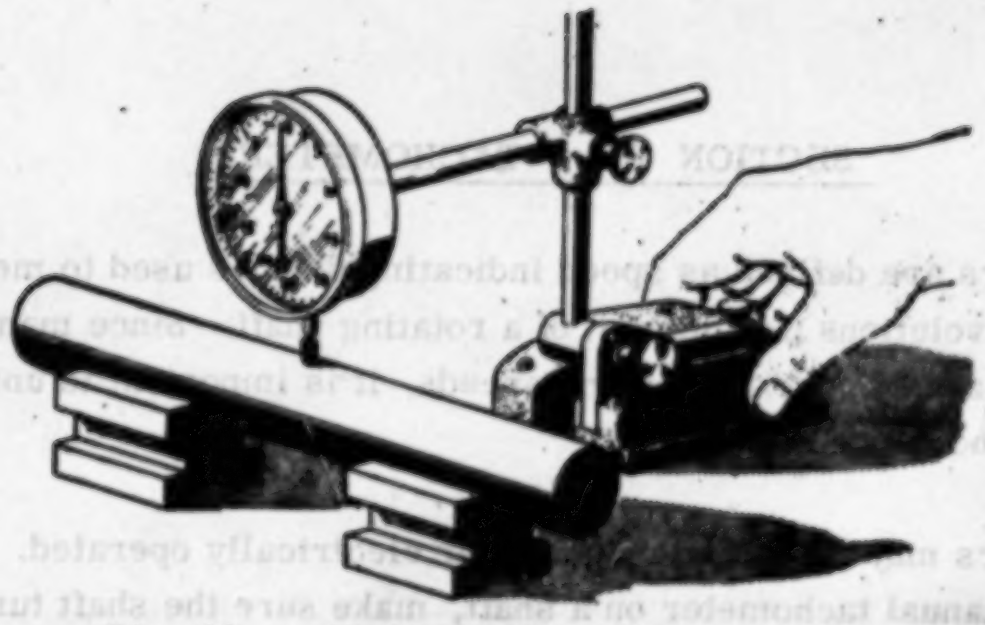


Fig. 19 Testing the roundness of a part.

dial is clamped in place by turning the bezel clamp screw. To check the shaft for concentricity, the shaft must be turned by hand. Irregularities in the shaft are noted by movements of the pointer.

To check the same piece for taper, first remove the V-block clamps, as it is only necessary to lay the piece in the blocks. Then follow the procedure outlined above. Adjust the indicator to the proper height on the pedestal spindle and bring the button of the indicator to bear on one end of the work piece. Adjust the dial so that the zero on the dial lines up with the pointer of the indicator. Now move the pedestal base on which the indicator is mounted so that the button of the indicator is brought to bear on the opposite end of the work piece. By detecting the deflection of the needle from zero, you can easily see the amount of taper in the shaft.

SECTION E -- TACHOMETERS

Tachometers are defined as speed indicating devices used to measure the rpm (revolutions per minute) of a rotating shaft. Since many engine tests are made at specified engine speeds, it is important to understand how the tachometer operates.

Tachometers may be either manually or electrically operated. When using the manual tachometer on a shaft, make sure the shaft turns the same speed as the crankshaft or you will not get an accurate reading of engine rpms. In many instances it is easy to take tachometer readings off the camshaft or balance shaft. Remember: on two cycle engines, (GM), these shafts turn the same speed as the crankshaft; on four cycle engines (CUMMINS), these shafts run at one-half the crankshaft speed. Consequently, any tachometer reading taken on the camshaft of a four cycle engine must be doubled to get true engine rpm.

A manual tachometer, see Figure 20, is used by holding its tip against the end of a rotating shaft. Make sure the end of the shaft is clean and that there is no slippage between the tip of the tachometer and the shaft. Read the speed directly on the tachometer dial, which is calibrated in revolutions per minute. No timing is necessary, as variations in speed will be reflected by movement of the pointer on the dial during the test.

STROBOSCOPIC ELECTRIC TACHOMETER -- A slightly less accurate but quicker method of obtaining engine rpm is through the use of an electric stroboscopic tachometer. A STROBOSCOPE is defined as a device that indicates frequency of operation by creating an optical illusion of slowing down or stopping a moving pattern, which is illuminated by a light that flashes at a known frequency. A STROBOSCOPIC ELECTRIC TACHOMETER is an instrument with a scale calibrated in flashes or in revolutions per minute. The stroboscopic lamp is directed

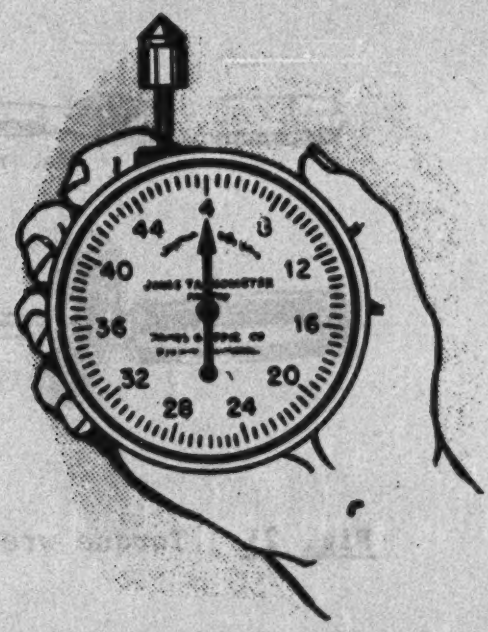


Fig. 20 Manually operated tachometer.

onto the rotating device (usually the flywheel) being measured, and the flashing rate is adjusted until the device appears to be standing still. The speed can then be read directly from the scale. Usually a chalk mark is placed on the rotating mechanism to be timed. When the chalk mark appears to be standing still, the speed can be read from the scale.

SECTION F -- TORQUE WRENCH

A TORQUE WRENCH, Figure 21, is used for work requiring a particular force (torque) to tighten bolts, nuts, cap screws, etc., to a desired degree of pressure. A dial or scale calibrated in foot-pounds indicates the degree of torque applied to the work. The pointer moves to the right or left of zero, depending on the bolt (left or right hand threads) being tightened. These wrenches are issued in several sizes, with 1/4, 1/2, or 3/4 inch square drives to receive socket wrenches. Large torque wrenches are capable of handling as much as 600 foot-pounds.

The torque wrench enables us to set up a nut or bolt when the force applied to the handle reaches the specified limit. Manufacturer's instructions specify these limits of turning force. Cylinder head nuts

and bolts, rod bearing caps, and other parts of internal combustion engines require torque wrench limits. Choose the proper size socket wrench square drive, then place socket wrench on work and pull the torque wrench handle in the desired direction to tighten the work. The tightening torque will be indicated on the dial or scale, depending on the type of torque wrench used.

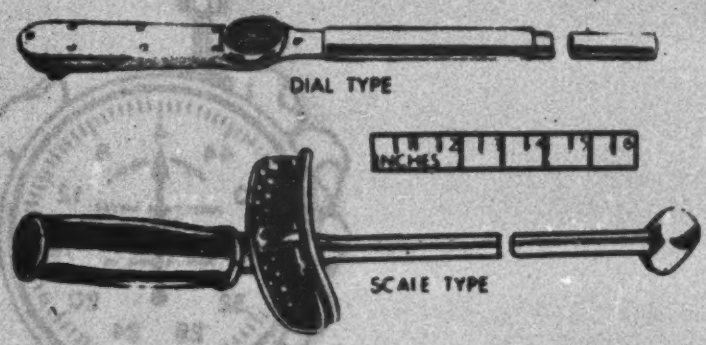


Fig. 21 Torque wrenches.

SECTION G -- THICKNESS (FEELER) GAGES

THICKNESS (FEELER) GAGES -- These gages are fixed in leaf form, which permits the checking and measuring of small openings, such as contact points, narrow slots, and so forth. Thickness gages are made in many shapes and sizes; usually two to 26 blades are grouped into one tool and graduated in thousandths of an inch. Most thickness blades are straight, while others are bent at the end, at 45 and 90 degree angles. Some thickness gages are grouped so that there are several short and several long blades together.

Thickness gages also are available in single blades and in strip form for specific measurements. In diesel maintenance, very often, go-no-go feeler gages are used. These gages have two thicknesses on one blade with a reading or thickness between the two. For instance, you may want to set a gap of .012 using a .011 to .013 go-no-go feeler gage. If the right setting has been made, the gage will pass through the opening over the .011 thickness, but not over the .013 thickness.

Figure 22 shows the various types of feeler gages.

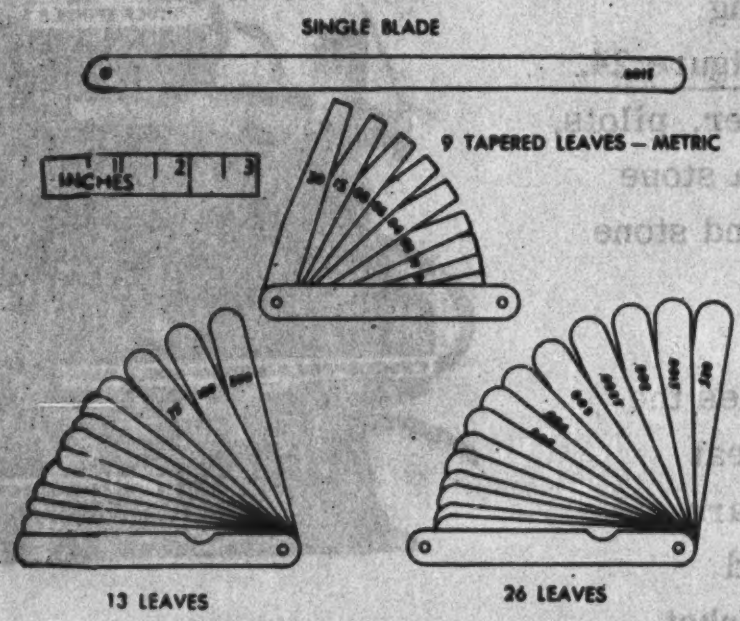


Fig. 22 Thickness (feeler) gages.

SECTION H -- VALVE REPAIR EQUIPMENT

Valve repair equipment is composed of an assortment of machine tools and components that are designed for reconditioning valves in internal combustion engines, in accordance with engine manufacturer's specifications.

VALVE REFACER -- The valve refacing machine, see Figure 23, is used to remove small pits or burns from the valve face. This is accomplished by clamping the valve stem in the chuck of the refacing machine and bringing the rotating grinding wheel into contact with the seating face of the valve.

Valve refacing machines have attachments for dressing grinding wheels, truing tappets, squaring valve stems, and for grinding valve rocker arm faces.

VALVE SEAT GRINDER- Valve seat grinding equipment, see Figure 24, consists of a driver, pilots, grinding stones, a stone dressing stand, and stone sleeves.

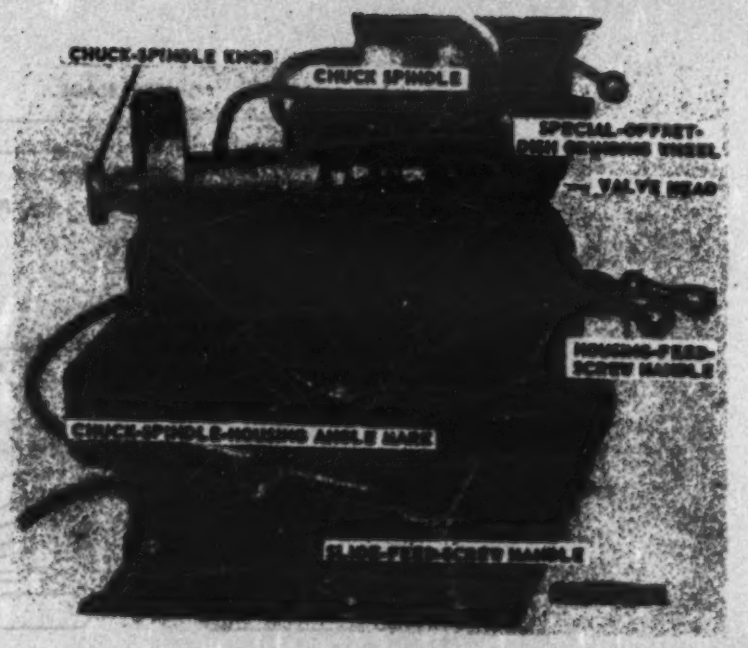


Fig. 23 Valve refacing machine.

The driver provides the power for valve seat grinding. There are different kinds and designs on the market, but one common type uses an angular head design to permit easier handling in confined spaces.

Fig. 24 Valve seat grinding equipment.

Most drivers incorporate a positive vibrating action which lifts the grinding stone from the seat once each revolution. This minimizes stone loading, speeds up grinding, and reduces stone wear.

Most valve guide pilots are of the self-centering type. Their function is to provide a rigid axis for the grinding stone sleeves, so that the valve seats are refaced concentric with valve guides. The self-centering pilots have two machine tapers: one at the top of the shank to fit the top of the valve guide, and one at the bottom to expand a split sleeve in the lower end of the guide, see Figure 25.

Fig. 25 Self-centering valve guide pilot.

The valve seat grinding stone sleeves are attachments that fit over the pilot and are threaded on one end for attaching the stone; see Figure 26. The upper end has a socket which forms a universal joint connection with the end of the driver spindle.

Fig. 26 Valve seat grinding stone sleeve.

Valve seat grinding stones are made in three grades: one grade is for average cast iron seats found in most engines; another is for faster grinding of hard steel, stellite, and other hard alloy inserts; a third is for "finish grind" on all seats. A threaded steel bushing is cast in the center of each stone to thread on the stone sleeve. After the stones are placed on the stone sleeve, they should be dressed on the stone dressing stand to establish a true angle to the pilot.

VALVE LAPPER - The hand valve lapper, see Figure 27, is a device that is used to lap engine valves in their seats. It consists of a pinion gearing enclosed in a heavy machined cast iron housing. An external crank handle drives the gears, which rotates a shaft. The end of the shaft is designed to hold any one of three driving blades for use on slotted valves. Non-slotted valves can be driven by a rubber suction cup that is supplied with a lapper. Two shafts are generally furnished: one short and one long.

VALVE SPRING TESTER-- A valve spring tester, see Figure 28, is used to test valve springs for proper tension. A valve spring that is too weak will not seat the valve properly, and thus will cause it to burn. A spring that is too strong will cause undue wear on the valve operating mechanism. The manufacturer's manual will give the proper spring tension required of the valve springs. Any valve springs that do not have the proper tension, or are warped, short, or broken, must be discarded and replaced.

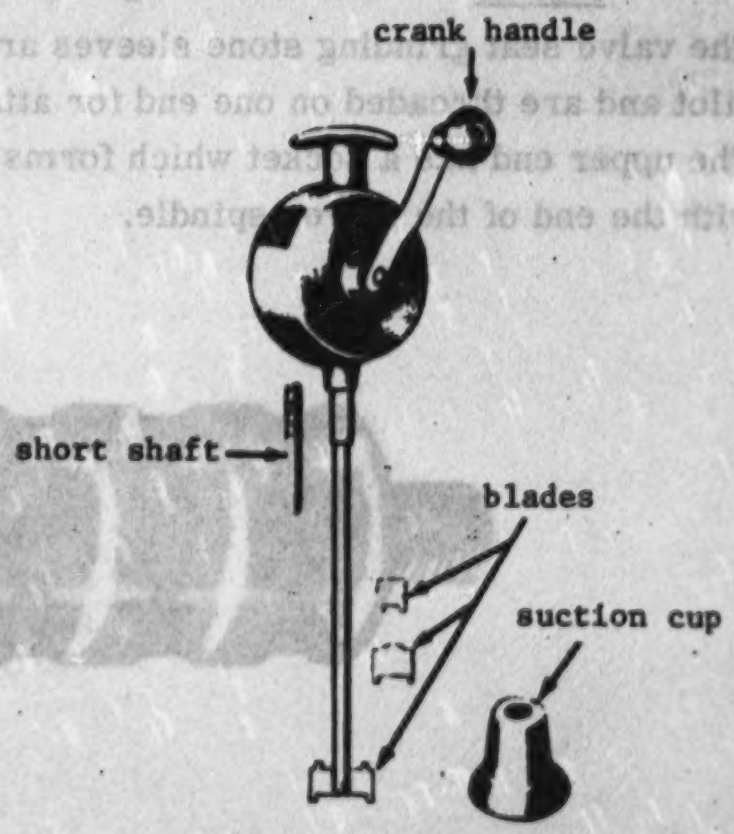


Fig. 27 Valve lapper.

DO NOT FILM THIS PAGE

VALVE SPRING COMPRESSOR -- This is the tool that compresses the valve spring so the retaining locks can be removed from the valve stem. Figure 29 shows this tool being used.

Room does not permit us to cover all of the tools used in diesel engine maintenance in this one unit. Other important tools will be discussed as we move through the course.

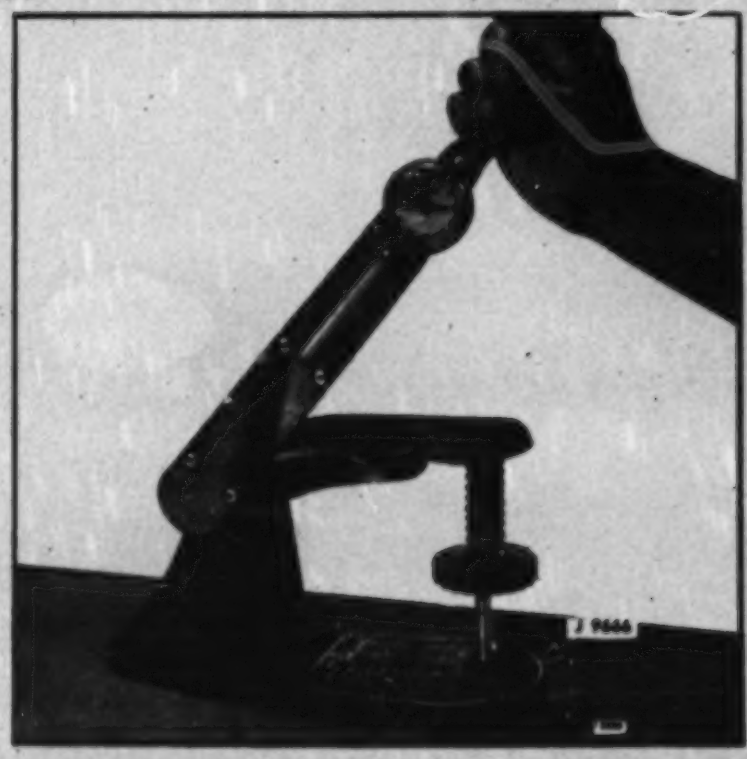


Fig. 28 Valve spring tester.

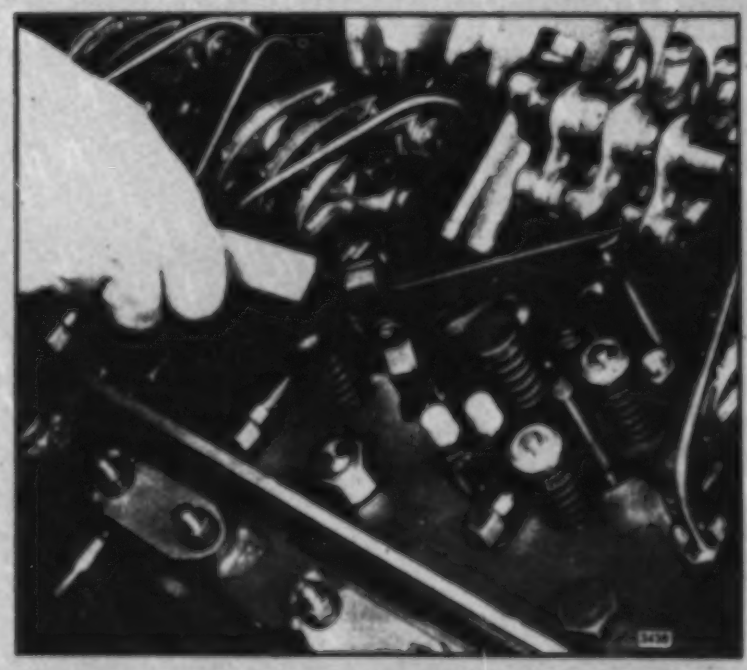


Fig. 29 Removing an exhaust valve spring.

DIDACTOR PLATES FOR AM 1-10D

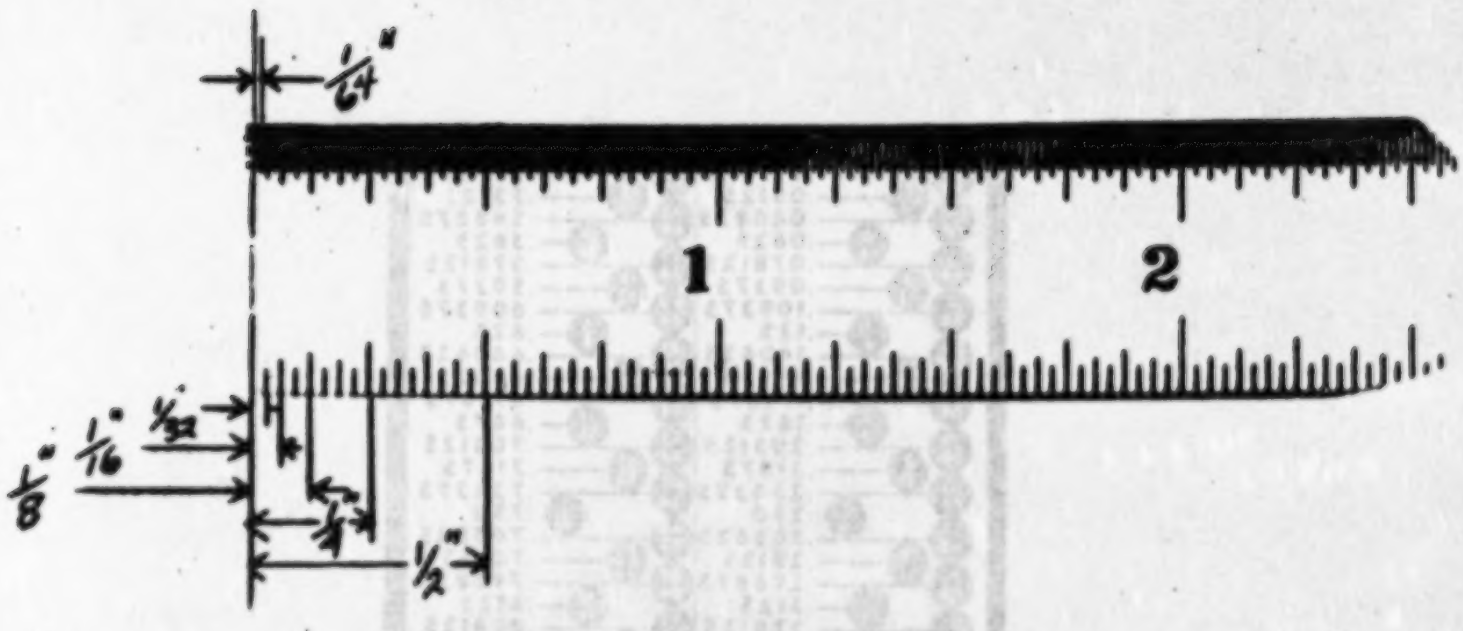
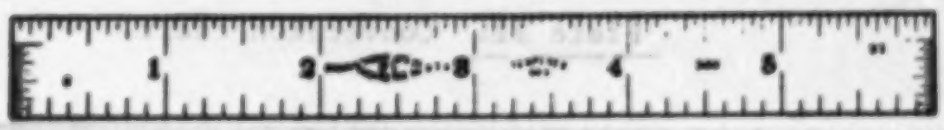
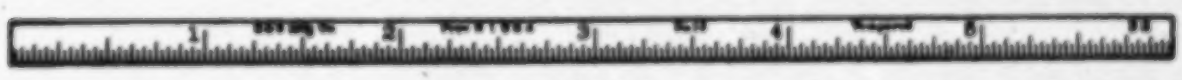


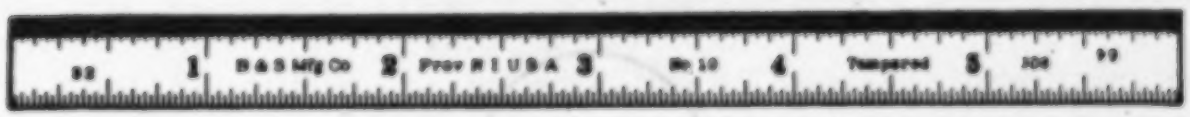
Plate I Division of an inch.



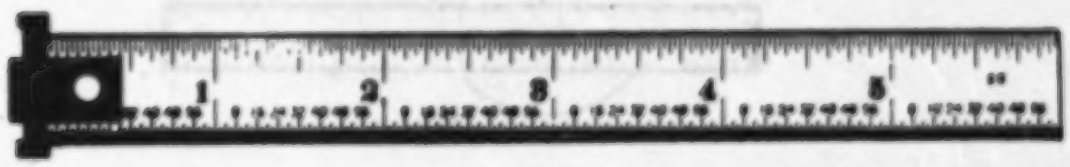
SIX-INCH – POCKET



NARROW



FLEXIBLE



HOOK

Plate II Different types of steel rules.

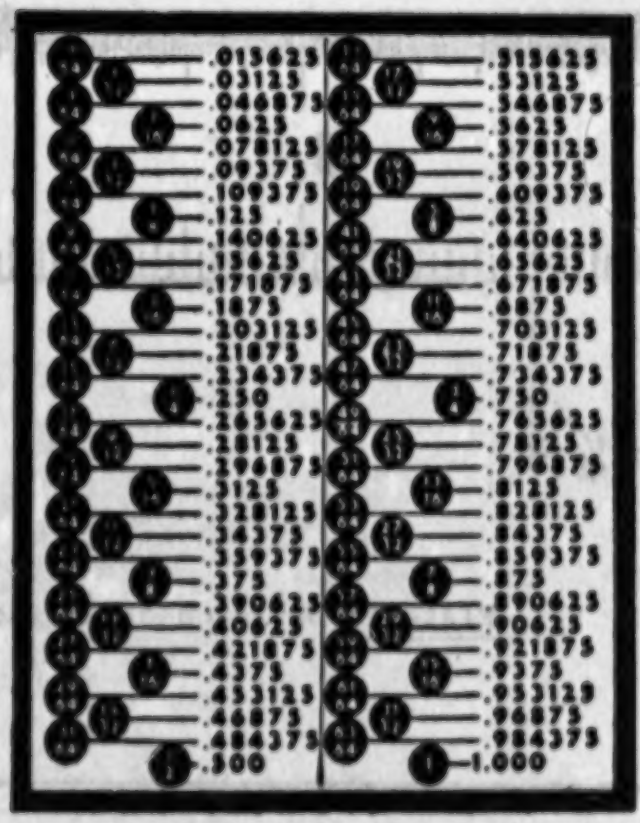


Plate III Conversion chart.

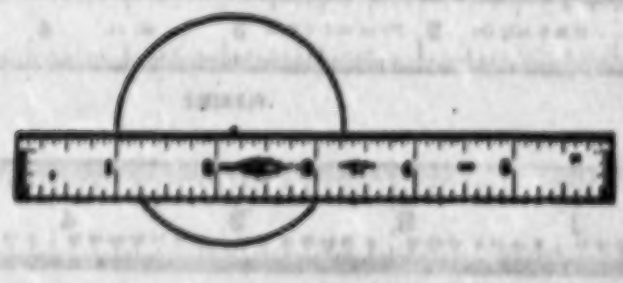


Plate IV Measuring across center to get true diameter.

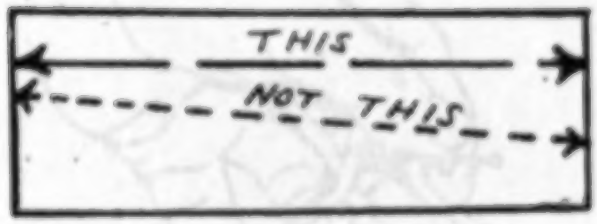


Plate V Measuring parallel.
with length measured.

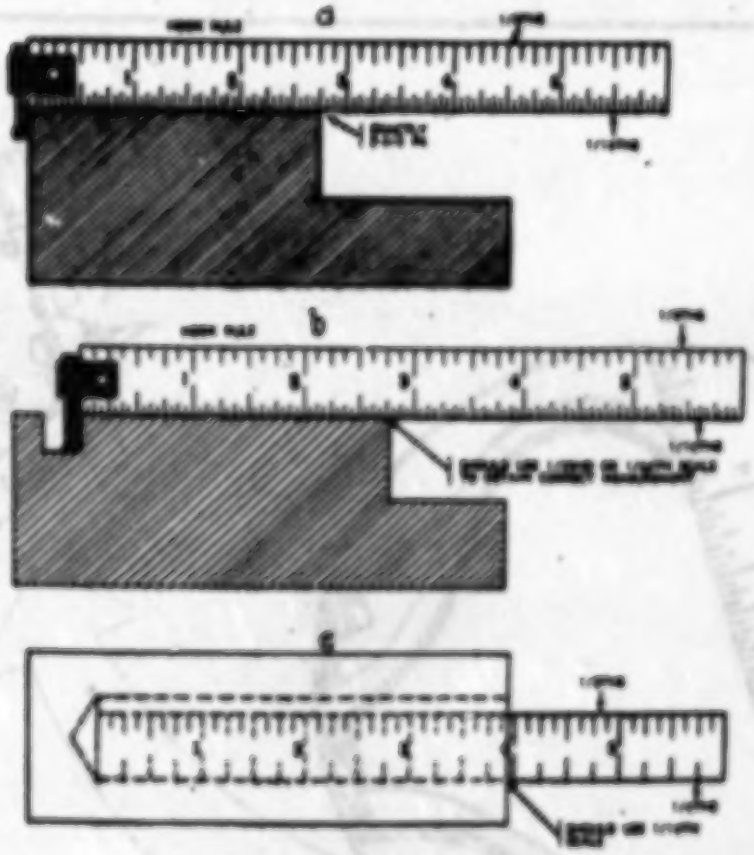


Plate VI Determining proper graduated scale.

Plate VII Caliper measurement.

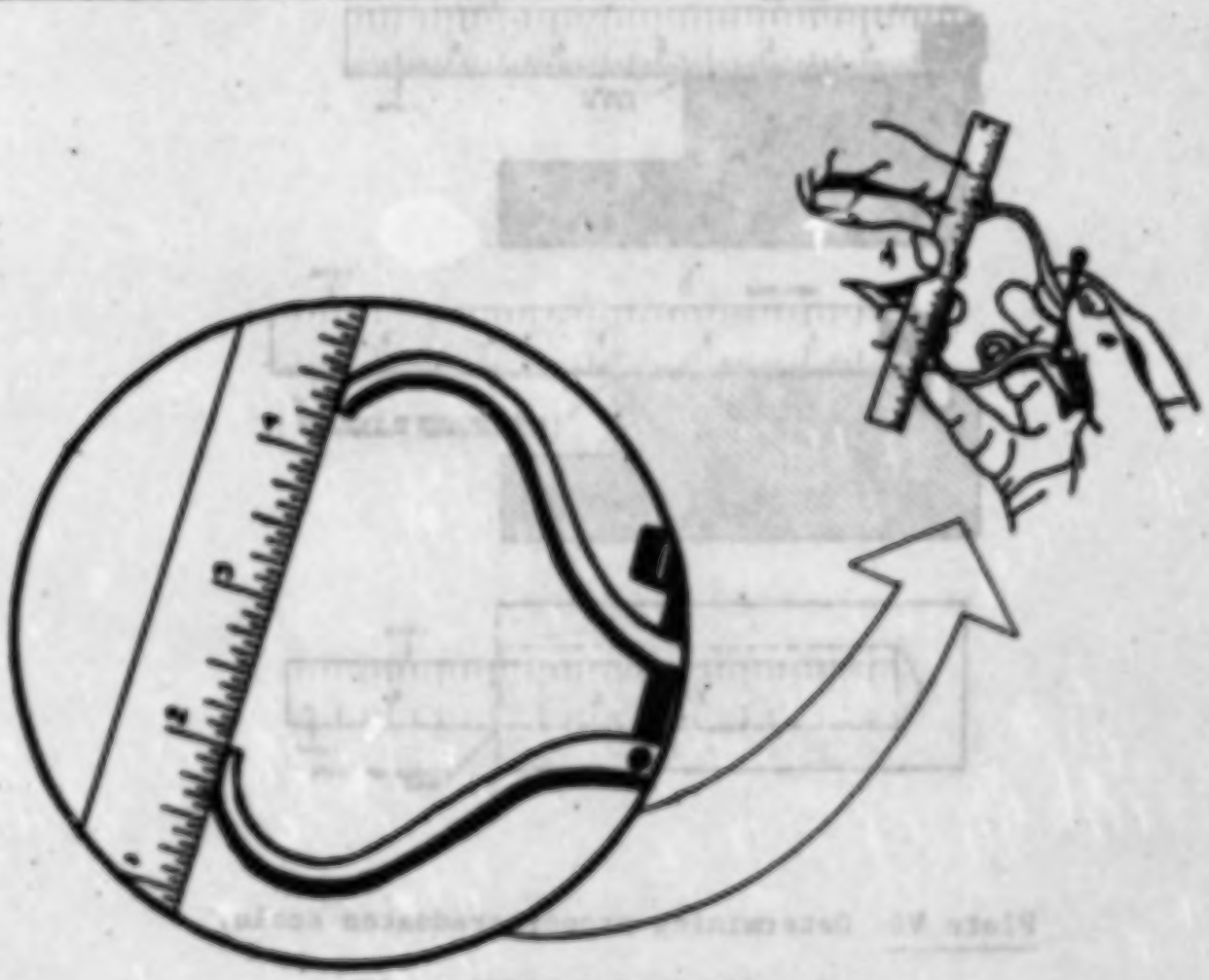


Plate VIII Rule designation.

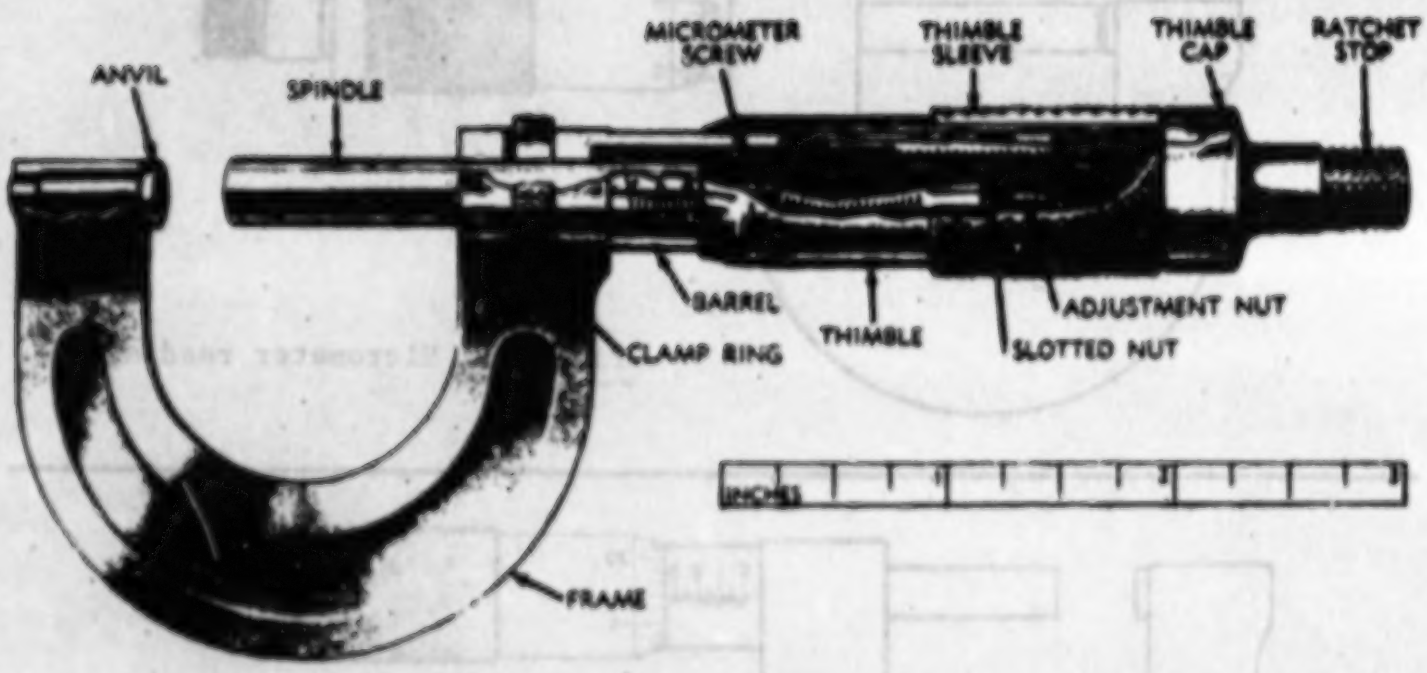


Plate IX Micrometer caliper - cutaway view.

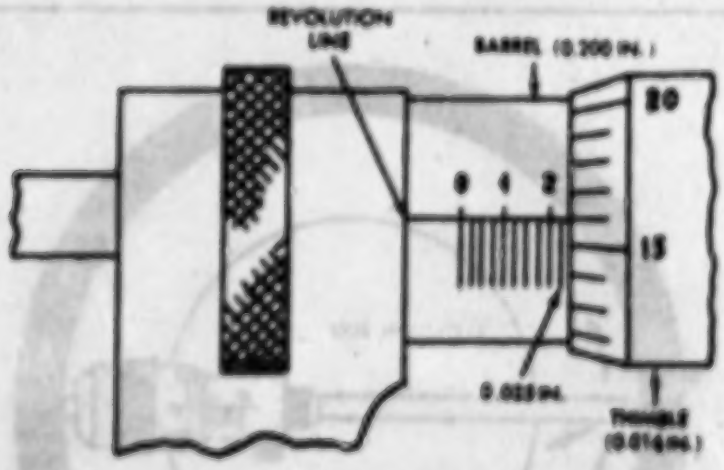


Plate X Reading standard micrometer scale.

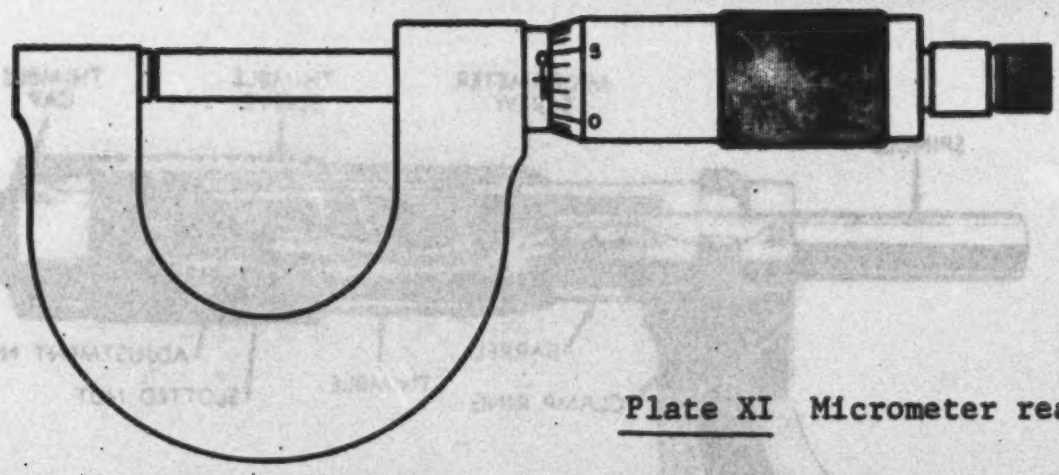


Plate XI Micrometer reading.

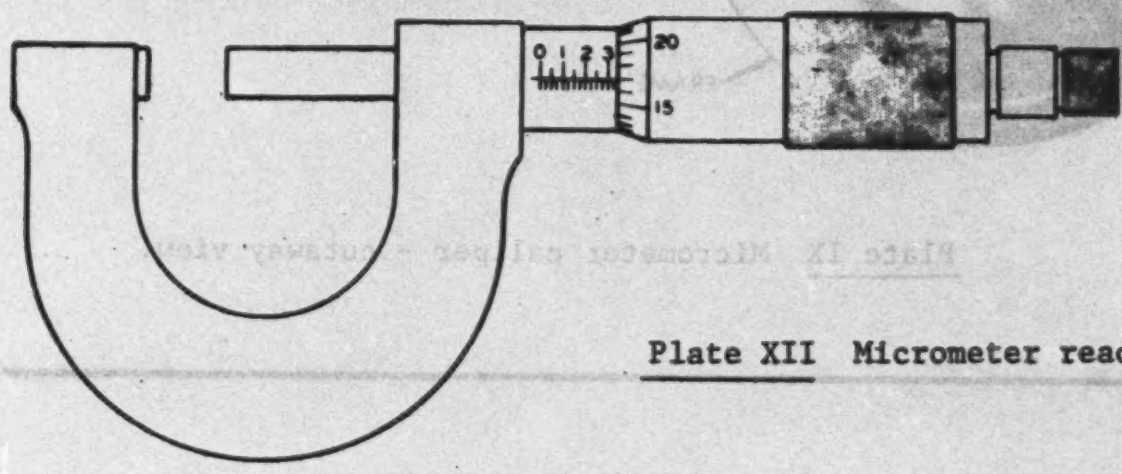


Plate XII Micrometer reading.

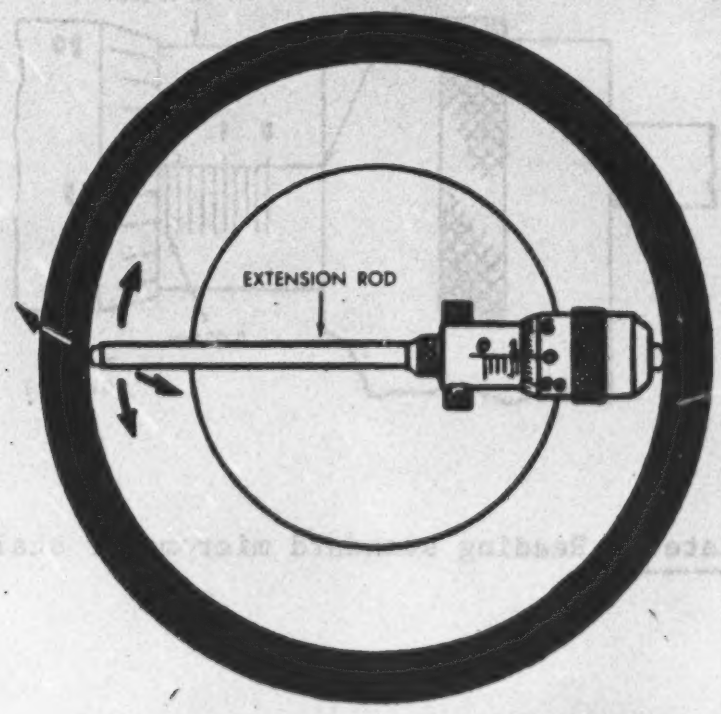


Plate XIII Inside micrometer.

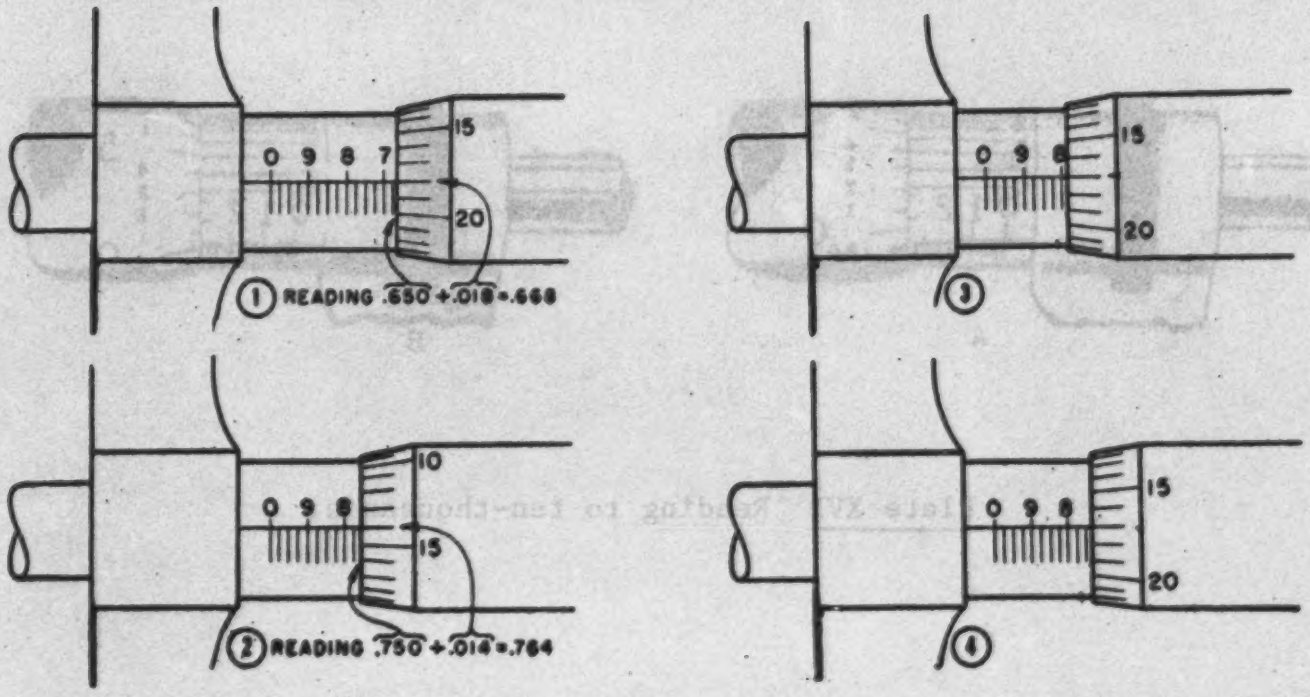


Plate XIV Readings on inside micrometers.

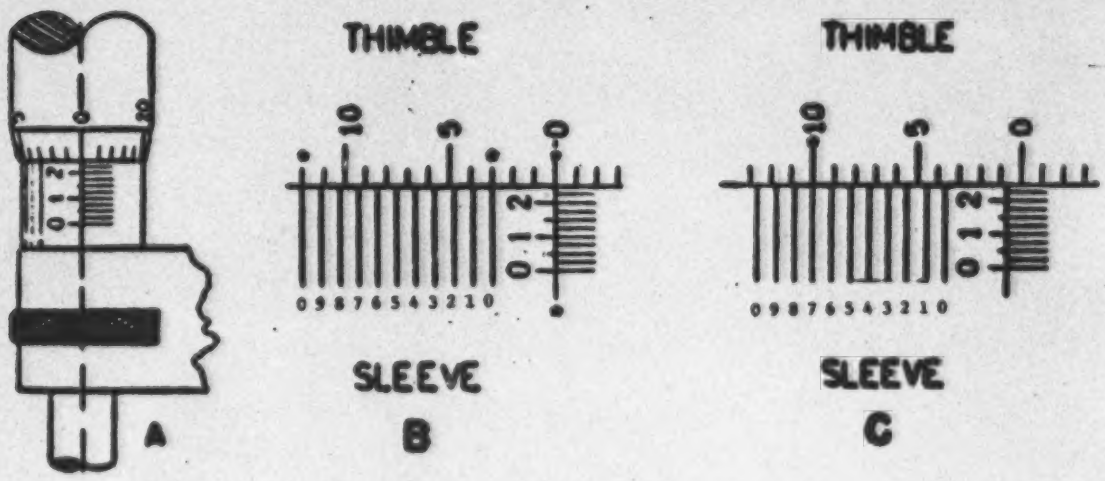


Plate XV Reading a vernier scale micrometer.

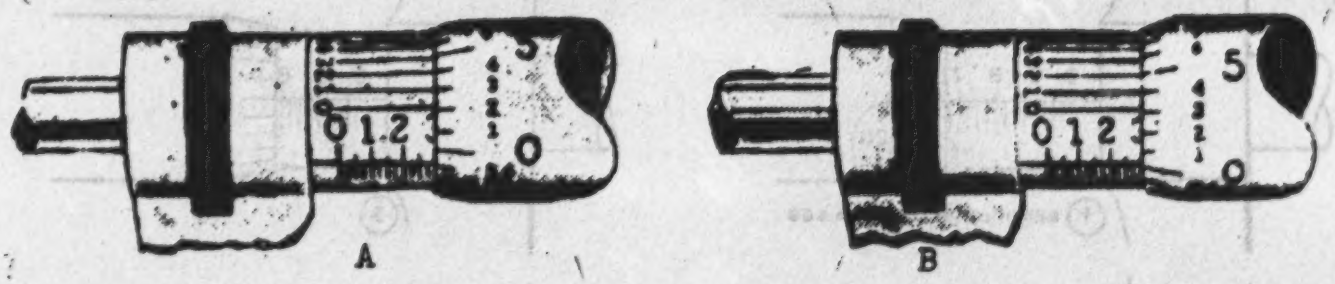


Plate XVI Reading to ten-thousands.

AM 1-10D
1/3/66

0

USE OF MEASURING TOOLS IN DIESEL MAINTENANCE

PART 1

Human Engineering Institute

Press A — 1

Check to see that timer is OFF

1

1

Off-the-highway equipment maintenance men are often called upon to use various types of measuring tools. These tools may be micrometers, calipers, gages, tachometers, etc. In using these tools and making calculations that are required, the man must know how to read scales and graduations, plus have a working knowledge of basic math.

This unit is designed to supplement unit AM 1-10 by covering the basic knowledge required in using measuring tools.

1

Press A — 2

2

The common unit of measurement for linear dimension is the inch. All measuring instruments which we use are calibrated from this standard inch.

In using dimensions, it is necessary to divide our smallest unit of measurement (inch) into smaller parts. To do this, consider the inch as being divided into 16 parts of identical length, which when assembled end to end equal an inch. Or, consider the inch as being broken up into equal parts of 32, 64, or 100. See Plate I.

1

Press A — 3

3

Any part of one is always a fraction. If one is divided into eight identical parts, each part would be one-eighth of the whole and would be expressed as 1/8. Two of these parts would be 2/8. This fraction could be reduced to 1/4, which is known as reducing a fraction to its lowest, simplest form.

Press A — 4

1

1

4

In fractions, all numbers above the line are called numerators, all below the line are called denominators. For instance, in a problem where two fractions are being added such as 1/4 + 2/4 = 3/4, the common denominator is 4. Always remember when adding fractions, the denominator must be the same. If they are not the same, they have to be changed. If 2/16 were to be added to 1/2, the 1/2 would be changed to _____.

A. 4/8 — 5
B. 8/16 — 6
C. 2/4 — 5

1

5

No, you are incorrect. Remember we said to add two fractions together, the denominators or numbers below the line had to be the same. You don't add apples and oranges and get apples, do you? Let's try another. Add 1/3 and 3/6 together. Before adding, the 1/3 would be changed to 2/6, right? Then our answer would be 5/6. Lets move on.

Press A — 6

1

6

OK. You are doing fine. Most measurements on diesel engines deal with decimals rather than common fractions, so let's move into what decimals are, and how to understand them.

The decimal system, or the system of tens which our system is called, can be used to express fractions of one inch. In this system, consider all numbers to the right of the decimal point as parts of one. For example, the number .1 would indicate 1/10 of one; or the number .4 would equal 4/10 of one; etc. What would be the next highest number after .9?

A. .01 — 7
B. 1.0 — 9
C. 10. — 8

1

7

No. You are incorrect. The more places you go the right of the decimal the smaller the number or parts of the one(1) become. More will be said on this later, so don't let it throw you. The important point here is to note where the decimal is. To go higher than .9, we have to move on the other side of the decimal, or 1., right? Let's move on.

Press A — 9

1

8

No. You have moved too many decimal places to the left. Remember we said everything to the right of the decimal was part of 1. So if we had .9, then we would have 9/10 wouldn't we? To add one more or go higher, we would have 10/10 which equals 1 complete whole, just as 8/8, 9/9, 7/7, 6/6, etc., equals 1. The correct answer is 1.0. Let's move on.

Press A — 9

1

9

OK, "1.0" is correct.

So far, we have gone only one place to the right of the decimal. In diesel engines, however, the tolerances are much greater than tenths of an inch.

Hundredths of an inch are shown by the second figure to the right of the decimal point. Example - .01 for 1 one-hundredth.

Press A — 9½

1

9½

Thousandths of an inch are shown by the third figure to the right of the decimal point, such as .001 for 1 one-thousandth.

Following this system, the figure .15 would be read as "fifteen hundredths". The figure .155 would be read as "one hundred fifty five thousandths".

In diesel work we even go down to millionths of an inch as for the tolerance between the shaft and plunger in the injector: 60 millionths, which is written this way:. 000060.

Press A — 10

1

10

Do not let the figure .000060 throw you, it is really very simple. The graduations to the right of the decimal are as follows:

.
0 tenths
0 hundredths
0 thousandth
0 10 thousandth
0 100 thousandth
0 millionths
0 10 millionths

Press A — 10½

1

10½

Always keep in mind that it's the last figure in the decimal that counts, whether it is zero or not. Suppose we wanted to write 60 thousandths in decimal form. How would it be written?

A. .060 — 13
B. .006 — 11
C. .60 — 12

1

11

No. You have chosen six thousandths. Remember we said the last figure is the one that counts. Since we want 60 thousandths, the zero is last, so it has to be three places over from the decimal. The answer is .060 for 60 thousandths.

Press A — 13

1

12

No. You have chosen sixty-hundredths. Remember we said the last figure is the one that determines the correct amount. Since we want sixty-thousandths, the zero has to be three places over from the decimal. The answer is .060 for 60 thousandths.

Press A — 13

1

13

OK, ".060" is the correct answer.

Now we can appreciate the importance of knowing some math. Most of the decimals we deal with in engine measurements are in the hundredth to thousandth range. For example, remember we talked of setting the valves with a feeler gage. The thickness of the blade was .011. According to what we have learned so far, this measurement is _____.

A. eleven-tenths — 14
B. eleven-hundredths — 15
C. eleven-thousandths — 16

1

14

No, eleven-tenths would be the same as $\frac{11}{10}$ or $1\frac{1}{10}$. Remember we said that 9/9 is the same as 1.

If you had $\frac{10}{9}$ in its proper form, it would be $1\frac{1}{9}$. Perhaps you had better review what we have covered so far before going on.

Read carefully.

Press A — 2

1

15

No. You were close, but you should leave one more place to the right:

"Eleven hundredths" is written $\frac{11}{100}$ or .11.

We gave the figure .011, which you would read as eleven thousandths.

Press A — 16

1

16

OK. "Eleven-thousandths" is correct. Now that we have discussed a little about fractions and decimals, let's see how the two compare.

Every common fraction has an equivalent decimal fraction as follows:

1/2 can be expressed as .500 or (1 ÷ 2)
1/4 can be expressed as .250 or (1 ÷ 4)
1/8 can be expressed as .125 or (1 ÷ 8)
3/4 can be expressed as .750 or (3 ÷ 4)

Press A — 18

1

17

OK You have answered one or more of the questions in this sequence of material incorrectly. You will be reviewing this data now. Please read carefully and think before you answer.

Press A — 2

1

18

However, common and decimal fractions of the same value may produce different results in actual use in measurement. In general, 1/8th suggests reading the dimension to the nearest eighth on the measuring scale, whereas .125 suggests reading the dimension to the nearest thousandth on the measuring scale. Reading the dimension to an eighth means taking a choice between 0 and 1/8th or between 1/8th and 2/8ths. Reading to a thousandth means discriminating between .124 and .125 or between .125 and .126 depending on whether the true dimension is under or over one-eighth. We can see that this makes a very great difference in the accuracy of the dimension.

Press A — 19

2

19

The machinists' steel scale or rule is one of the most frequently used measuring tools. It is a strip of high grade steel accurately divided into inches and fractions of an inch. The overall length of the scale may be 6, 9, or 12 inches, or any other length that may be convenient for the type of work being performed. For many ordinary uses, a 6 inch flexible steel scale is the most practical.

Press A — 20

2

20

The most common type of rule is graduated on one side to show divisions of the inch into 8ths along one edge, 16ths along the opposite edge, and on the reverse side the inch is divided into 32nds and 64ths. Another rule coming into greater use is graduated on one side to show divisions of the inch by 16ths and 32nds, and on the reverse side by 64ths and 100ths. This makes it possible to obtain rough decimal readings directly without running the risk of making errors in converting fractions into decimals or decimals into fractions. Plate II shows the many types of steel rules in use today.

The overall length of any accurately made rule doesn't matter because _____. Choose one.

A. it is still divided into 100ths of an inch. — 21
B. the length of an inch is the same on all rules. — 23
C. measuring can be started from either end. — 22

2

21

No. You are incorrect. Remember we said some rules are graduated differently. The most common type is divided into 8ths, 16ths, 32nds, and 64ths. However, no matter what rule is used, an inch is the same distance on all rules.

Press A — 23

2

22

No. Measuring cannot be started from either end of the rule. All rules start with (0) on one end and increase in graduations to the other. The overall length of an accurately made rule doesn't matter, because the length of an inch is the same on all rules.

Press A — 23

2

23

OK, let's move on.

Most maintenance men either carry pocket cards or have access to wall charts that show fraction/decimal equivalent conversion tables; see Plate III. These charts are very helpful because _____.

A. measurements taken must be converted from decimals to fractions. — 24
B. there is less chance of human error. — 25
C. most dimensions are given in fractional form. — 24

2

24

No. The desired measurement may be either in fraction or decimal form and to convert it mentally involves the human error factor. In addition, the maintenance man can work much faster if he doesn't have to figure each calculation.

Press A — 25

2

25

OK. Not only is there less chance for error, but instant conversion is faster and more economical.

There are certain precautions that must be followed when taking measurements with a rule. When measuring inside or outside diameters, measure across the exact center of the circle, see Plate IV. When measuring for true dimensions, as in Plate IV, you can be sure of an accurate reading when _____.

A. you obtain the greatest dimension. — 28
B. the rule is perfectly horizontal. — 26
C. the center of the circle is under the center of the rule. — 27

2

26

No. The rule could be exactly horizontal and be lower or higher than the diameter dimension. The correct reading is obtained when you get the largest dimension.

Press A — 28

2

27

No. There is no way of knowing whether the center of the circle is under the rule center. The correct reading is obtained when you get the largest dimension.

Press A — 28

2

28

OK. Another point to remember is that when measuring the length of a piece, be sure the scale is parallel with the length to be measured, see Plate V.

When measuring for a true length of the piece, as in Plate V, you can be sure of a true measure when _____.

A. you obtain the greatest length. — 29
B. the rule is perfectly horizontal. — 30
C. you obtain the smallest dimension. — 31

2

29

No. Look at Plate V again. If you obtained the greatest dimension, the measurement would be from corner to corner, not giving the measurement needed. The correct answer is "getting the smallest dimension."

Let's move on.

Press A — 31

2

30

No. As in the circle measurement, even though the rule is horizontal, the rectangle may not be and thus gives a wrong indication. The correct answer is "getting the smallest dimension." Let's move on.

Press A — 31

2

31

OK, the smallest dimension would be the correct one.

When using a rule to check a dimension, the proper graduated scale should be used to control the reading of the dimension. See Plate VI (a). If the piece being measured lines up between two graduations on the scale as shown in Plate VI (b) and (c), and it is not possible to read this dimension to 1/16 on the 16th scale, the 32nd scale should be used. If it is still impossible to read a dimension to 1/32nd, the 64th scale should be used.

Press A — 32

2

32

Before moving on, let's see if you understand the principles involved in this last sequence of material.

If you are given dimensions of 1.499" minimum and 1.501" maximum for the allowable tolerances of a replacement part, which of the following would be permissible?

A. $1\frac{31}{64}$" — 33
B. $1\frac{1}{2}$" — 34
C. $1\frac{1}{8}$" — 33

2

33

No, your answer is incorrect. Both $1\frac{31}{64}$ and $1\frac{1}{8}$ are beyond the allowable tolerance. Check the conversion chart, Plate IV.

Press A — 34

2

34

OK. $1\frac{1}{2}$ converted to decimal form is 1.500, making this within the allowable tolerance.

A new bearing has a thickness of .1548" to .1553". The minimum thickness of a worn standard main bearing shell is .153". Worn bearings any thinner than this must be discarded. A bearing that has been worn to a thickness of _____ must be discarded.

A. .1529" — 36
B. .1530" — 35
C. .1547" — 35

2

35

No. This dimension is within the allowable tolerances for use. Remember, we said if the thickness was less than .153, the bearing had to be discarded.

Press A — 36

2

36

OK. Any thickness less than .153 must be discarded.

In the text AM 1-10 we discussed calipers, dividers, and various other tools used to measure outside and inside diameters of rods, shafts, cylinder liners, piston bores, etc. Let's review the math behind these tools to learn more about them.

Press A — 38
(X) C — 37

2

37

You have answered one or more of the questions in this sequence of material incorrectly. It will be better if you review this data again to establish it in your mind. Read carefully and take your time in answering.

Press A — 18

2

38

The word tolerance has been mentioned several times in this lesson; let's see what is meant by the word. Tolerance of a dimension could be thought of as a measurement which has an upper and lower limit.

For instance, here is a given dimension: 2.000". This may be found in the maintenance manual as 2.000 ± .010". This means that the limits of the dimensions are: Lower -- 1.990", upper -- 2.010".

This indicates that any dimensions between the upper and lower reading is permissable.

Press A — 39

39

Here is a given dimension from a manual: 4.050" ± .050".
What is the upper limit? What is the lower limit?

A. 4.050" 4.000" — 40
B. 4.100" 4.000" — 41
C. 4.150" 4.000" — 40

40

Your answer is incorrect. The manual said 4.050" ± .050". This means that the upper limit is 4.050" + .050" = 4.1000" and the lower limit is 4.050" - .050" = 4.000".

So, a part that runs between 4.000" and 4.100" will fit, and anything above or below will not fit. Remember to watch your addition when using the decimal point.

Press A — 41

41

OK. The limits for 4.050" ± .050" are upper: 4.100", lower 4.000".

Tolerance, then, is the overall amount between the upper and lower limits. Thus, if we want to tell someone the tolerance for 4.050" ± .050", we need to add or subtract the limits.

Press A — 42

42

We subtract the lower limit from the upper limit, or:

Upper limit: 4.100"
Lower limit: -4.000"
.100"

Now try this: find the tolerance of a dimension having the upper limit of 7.312" and a lower limit of 7.309".

A. .003" — 45
B. 621" — 43
C. .120" — 43

43

Your answer is incorrect. To find the tolerance simply subtract the lower limit from the upper limit.

Thus 7.312" Upper limit
-7.309" Lower limit
.003" Tolerance

What is the tolerance of a dimension having upper limit 1.020" lower limit .9000"?

A. 120" 44
B. 1.20" 44
C. .120" 45

44

Your answer is incorrect. Ask your instructor for help in subtracting decimals. It's a lot like subtracting dollars and cents.

Just as $1.02 -.90 .12 so 1.020" -.900" .120

Try the original problem again. Press A — 42

45

Correct. Now we know that tolerance is simply the overall amount between the upper and lower limits and is determined by _____.

A. the dimension given in the manual. — 46
B. the uppermost and lowermost size acceptable. - 47
C. the dimension given minus the tolerance. — 46

46

No. Your answer is incorrect. It will be best if you review this section again. Read carefully and think before you answer.

Press A — 39

3

47

Correct.

Now if we were measuring the outside of a cylinder liner, see Plate VII, after a setting is obtained, the calipers are transferred to the rule, as in Plate VIII.

What would the diameter be in inches?

A. $2\frac{1}{8}$" — 48
B. $2\frac{9}{8}$" — 49
C. $2\frac{9}{16}$" — 50

3

48

Your answer is incorrect. You didn't count the divisions properly. Count them again and then choose the correct answer.

Press A — 47

3

49

Your answer is incorrect. You said $2\frac{9}{8}$". The scale is in 16ths, which means that the answer you chose could also be written $2\frac{10}{16}$". This means that the fractional part of the measurement is over half an inch. Look again. (Keep in mind what scale we are working with).

Press A — 47

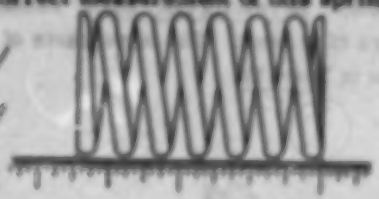
3

50

$2\frac{9}{16}$ is the correct answer.

Now what is the correct measurement of this spring?

A. $1\frac{3}{4}$ — 51
B. $1\frac{5}{16}$ — 51
C. $1\frac{23}{32}$ — 52



3

51

Your answer is incorrect.

Remember, the scale we are using in this problem is 32nds. Look at the drawing very closely and see where the measurement starts, then choose the correct answer.

Press A — 50

3

52

Correct. $1\frac{23}{32}$" was the correct measurement.

Many times the ends of rulers become worn. Because of this we see the use of the inner inch divisions rather than starting from the end. Supposing you are measuring the diameter of a pipe. You measure it three times and get three different sizes.

What would be the correct size?

A. $2\frac{1}{2}$" — 53
B. $2\frac{9}{16}$" — 53
C. $2\frac{17}{32}$" — 54

3

53

Your answer is incorrect.

We look for the largest measurement in diameters. Try again.

Press A — 52

3

54

Correct. We were looking for the largest measurement, which is 2 17/32". Also remember that when measuring the length of an object, the smallest measurement will be the nearest to the actual length.

Now, the 2 17/32" mentioned above in decimal form would be _____. Choose one.

A. .21732 - 56
B. 2.2217 - 55
C. 2.53125 - 56

55

No. Look at your conversion chart in Plate IV. The answer is there. Try again.

Press A - 54

56

Correct. Now you're getting the idea.

Now look at Plate VII. The calipers used in this picture are the _____.

A. inside measuring type. - 57
B. outside measuring type. - 58
C. inside diameter measuring type. - 57

57

No. These are the outside measuring type used to measure pipe, shafts, etc., discussed in the class text. Perhaps you should review AM 1-10 before moving on.

Press A - 56

58

Correct. Now let's refresh our memory about MICROMETERS and how to read them accurately. As we learned in class, the micrometer is used for measurements requiring precise accuracy. The general abbreviation is "mic".

Press A - 59

59

There are outside "mics" used to measure the outside of shafts such as a crankshaft. Inside "mics" are used for measuring the insides of holes, such as piston bores.

There are depth "mics" used to measure holes, grooves, and slots. Screw thread "mics" measure outside diameters of screws. The basic parts of a "mic" are shown in Plate IX.

Press A - 60

60

Reading the micrometer is only a matter of reading the micrometer scale or counting the revolutions of the thimble and adding to this any fraction of a revolution.

The "mic" screw has 40 threads per inch. This means that one complete and exact revolution of the screw moves the spindle away from or toward the anvil exactly 0.025 inch. The lines on the barrel, (see Plate X) increments 0.025 inch, and each fourth line is numbered - 1, 2, 3, and so on.

The thimble edge is marked off in 25 parts, each line indicating 0.001 inch, 1/25 of the 0.025 inch covered by one revolution of the thimble.

Read this frame again before going on.

Press A - 61

61

Every fifth line on the thimble is numbered to read a measurement in thousandths of an inch. To move the spindle on the micrometer one inch in either direction, the thimble has to make _____ complete revolutions.

A. five - 62
B. forty - 63
C. ten - 62

62

No. Remember we said the screw had 40 threads per inch and with each revolution of the thimble the spindle moves .025 of an inch. So, 40 x .025= 1.0. For every inch moved, the spindle has to make forty revolutions.

Press A — 63

63

Correct. For every inch moved, the spindle makes forty complete revolutions. One revolution would move the spindle _____ of an inch.

A. 1/25 — 64
B. 1/1000 — 65
C. 1/40 — 66

64

No. If one complete revolution moves the spindle 1/25 of an inch then the thimble would make 25 revolutions to move one inch, wouldn't it? Think and try again.

Press A — 63

65

No. You are confused with the scale on the thimble. When the thimble is moved a complete revolution it moves the spindle 1/40 of an inch.

Press A — 66

66

OK. For every complete revolution of the thimble, the spindle moves 1/40th of an inch.

Now, notice the notches on the thimble itself. There are 25 marks, and each one, as we learned before, represents 1/25 of a complete revolution. So if we multiply 1/25 x 1/40 we get 1/1000. This means that for every notch turned the spindle will move .001 of an inch. If you turned the thimble 4 notches, the spindle would move _____ of an inch.

A. .004 — 68
B. .0025 — 67
C. .04 — 67

67

No. Each notch represents .001 of an inch movement. Now multiply 4 x .001. The answer is .004 of an inch, right?

Press A — 68

68

OK. ".004" of an inch is correct.

How many notches would you have to turn to make it move one-half inch? Choose one.

A. 250 notches. — 69
B. 500 notches. — 70
C. 750 notches. — 69

69

No. Think now, there are 25 notches on the thimble and it takes 40 revolutions to move an inch. To move one inch, wouldn't you multiply 25 x 40 to determine the number of notches that you passed? What would you do for one-half inch? Try this question again.

Press A — 68

70

OK. Now let's take some readings using a "mic". Look at Plate X again. The total measurement reading on this "mic" is 0.241". How did we arrive at that? Notice the barrel is showing the number "2". This means we have 0.200 inches to start with. The number of lines visible between the "2" mark and the thimble edge is 1. We know this is equal to 0.025 of an inch. The highest number on the thimble that has passed the revolution line is 16. Since each notch represents .001 of an inch, we have .016. Add these together and we get 0.241.

Press A — 71

4

71

Now, look at Plate XI and choose the correct reading.

A. 0.231 — 72
B. 0.025 — 73
C. 0.028 — 74

4

72

No. Your answer is incorrect. It will be best if you review how we got the reading on Plate X again. Read carefully and think before you answer.

Press A — 70

4

73

No. You are close, but you failed to add correctly. Don't forget it is the sum of the two readings on this picture. Try again.

Press A — 71

4

74

OK. You are getting the idea. Let's try another. Plate XII has a reading; what is it?

A. 0.325 — 75
B. 0.317 — 76
C. 0.342 — 77

4

75

No. You failed to account for the reading on the thimble, which is 17 or 0.017. Let's go over this again; read carefully.

Press A — 74

4

76

No. You added the 3 only on the barrel, not the 1 mark between the 3 and the thimble edge. Try it again now and don't leave anything out.

Press A — 74

4

77

OK. You are doing fine. Before going on, if you would like to review this section Press B, if you want more new material Press A.

A — 79
B — 58
(X) C — 78

4

78

OK. You have answered one or more of the questions in this sequence of material incorrectly. It will be best if you review the material again to establish it in your mind. Read carefully and take your time in answering.

Press A → 58

4

79

Both the depth micrometer and the inside micrometer are different from the one we have been discussing in that the barrel is graduated and read from right to left. Also, the thimble is graduated from top to bottom. Plate XIII shows an inside micrometer. The main point to remember is that:
You read what you don't see and read it backwards.

Press A — 80

5

80

In Plate XIV (1) the micrometer reads 0. 668. Let's see how this was obtained. The number "6" is concealed by the thimble. Remember, there are four spaces between the numbers. If only one complete space is shown, then there are two complete ones that are covered up. So we have 0. 650 so far. Now the thimble reads 0. 018, so we have a total of 0. 668.

Press A — 81

5

81

In Plate XIV (2), we see that the "mic" reads 0. 764, lets see how this is obtained. First, the "7", not shown, is concealed by the thimble. Second, there are 2 complete notches, also not shown, giving us . 050. Third, the thimble reads 0. 014. Total these up and we have 0. 764.

Now the reading on Plate XIV (3) is _____.

A. 0. 817 — 82
B. 0. 792 — 84
C. 0. 717 — 83

5

82

No. Your answer is incorrect. Remember, this type of "mic" is read from right to left, and you read what you cannot see. The "8" is visible here, so the reading must be something less than 8. Try again.

Press A — 81

5

83

No. You forgot to add the amount from the barrel. What about the three complete notches not shown between 7 and 8?

Try again.

Press A — 81

5

84

OK. First, we have 0. 700 (not shown); second, we have three covered notches, each equalling . 25, making 0. 075. Third, we have 0. 017 on the thimble, making a total of 0. 792.

You are doing fine.

Plate XIV (4) shows another reading; what is it? Choose one.

A. . 02617 — 85
B. 0. 767 — 86
C. 0. 742 — 87

5

85

No. You are reading from left to right. Remember on this "mic", the figures are read from right to left, or what cannot be seen. Try again.

Press A — 84

5

86

No. You counted too many notches on the barrel. Notice there are 2 full notches shown and one-half of one is covered up, this leaves 1 full notch. Try it again.

Press A — 84

5

87

OK. Now you're getting it. First, we have 0.700, second, there is one full notch totaling 0.025, third, reading the thimble, we have 0.017, total them up and we arrive at 0.742.

Press A — 88

5

88

Many times, people not familiar with shop talk are confused about the terminology used to describe "mics". For instance, there are 1-2" "mics", 0-1" "mics", or a 5-6", etc. Let's say we have a 0-1 inch "mic". This means any thickness from 0-1 inch can be measured, but nothing above an inch because the spindle will not move away from the anvil more than an inch.

Press A — 90

(x) C - 89

5

89

Yo.: have answered one or more of the questions in this sequence of material incorrectly. It will be best if you review the material again to establish it in your mind. Read carefully and take your time in aswering.

Press A — 79

5

90

Suppose we have a 1-2 inch "mic". This means that measurements can only be taken if the piece is over 1 inch but less than 2 inches. Use caution when measuring with these "mics" and others like them, because it is easy to forget that one or more inches are built in. For example, if a piece had a diameter of 1.496 inches, a _____micrometer should be used.

A. 3-5 — 91
B. 0-1 — 91
C. 1-2 — 94

5

91

No. We wanted a measurement of approximately $1\frac{1}{2}$ inches. A 3-5 inch "mic" measures only between 3-5 inches, the same as the 0-1 inch "mic" measures only between zero and one inch. Suppose you had a piece 4.096 inches long. You would need a _____"mic" for this measurement.

A. 2-3 — 93
B. 4-6 — 92
C. 0-1 — 93

5

92

Correct. Now you have it. Let's move on to even finer measurements using "mics".

Press A — 94

5

93

No. You still don't understand. We were measuring a piece between 4 and 5 inches. How could we use a 2-3 inch, or a 0-1 inch "mic"? Let's review.

Press A — 88

5

94

OK. You have it now. So far we have discussed only measurements to 1/1000 of an inch. Since many diesel parts are precision made we need a finer instrument, something that will measure to 1/10000 of an inch. These micrometers are called "vernier mics" and are graduated in ten-thousandths (.0001) of an inch. Plate XV shows a vernier scale micrometer.

Press A — 95

5

95

Reading a ten-thousandths "mic" is exactly the same as reading the others except one more step is required. In Plate XV (a) and (b), the reading is 0.2500", let's see why. First, the (2) on the barrel is showing and representing 0.200; second, there are two additional lines visible on the barrel representing 0.050"; third, since 0 on the thimble coincides with the longitudinal line on the barrel, there is no quantity or 0.000; and fourth, the "0" lines on the vernier match up with the lines on the thimble, so no reading again 0.0000. Totaling this up we have 0.2500 of an inch.

Press A — 96

5

96

Now, look at Plate XV(c). The reading here is 0.2507, let's see why. The first two steps are the same as before. We have a 2 indicating 0.200 and we have two notches, indicating 0.050.

Notice the longitudinal line on the barrel is between the "0" and the "1" on the thimble; this indicates that a 10,000th of an inch reading must be added.

Now look for a line on the thimble that coincides with one on the vernier (barrel). Right, it is 7. This means we add .0007 to the total or 0.2507.

Press A — 97

5

97

Look at Plate XVI (a). What is the reading on the "mic"?

A. 0.3001 — 98
B. 0.2991 — 100
C. 0.2993 — 99

5

98

No. The "0" on the thimble is below the longitudinal line on the barrel which indicates only 3 full notches showing between the 2 and 3. Try again.

Press A — 97

5

99

No. But you are close. Notice the notch on the thimble does not line up with the 3 on the the vernier. Which one does line up? Try again.

Press A — 97

5

100

OK. The answer is 0.2991. Now you're getting it. Look at Plate XVI (b) and pick a reading below that fits.

A. 0.3000 — 101
B. 0.3001 — 102
C. 0.3003 — 102

5

101

No. Notice the "0" on the thimble does not line up with the longitudinal line on the barrel. This suggests there is a ten-thousandths reading that has to be added. Try again.

Press A — 100

5

102

No. The mark on the thimble does not line up with the "3" vernier mark on the barrel. Which one does? Try again.

Press A — 100

5

103

OK. The correct reading is 0.3001 because the mark on the thimble lines up with the "1" mark on the vernier.

That completes this lesson on tools. More about tools will be covered later in the program. If you want to review this last portion of the tape Press A. If not Press REWIND.

A — 94

5

104

You have answered one or more of the questions in this sequence of material incorrectly. It will be better if you review the material again to establish it in your mind. Read carefully and take your time in answering.

Press A — 94

5

DO NOT FILM THIS PAGE

INSTRUCTOR'S GUIDE

Title of Unit: Use of Measuring Tools in Diesel Maintenance **AM 1-10**
1/ 3/ 66

FIRST: Be sure all questions have been answered that students might have on home study units.

OBJECTIVES: By the end of class, each student should know:

1. Why it is important to understand the use of measuring tools in diesel maintenance.
2. The basic math that surrounds linear measurement.
3. The proper use of using rules and tapes for measuring.
4. How to read rules and tapes of different graduations.
5. The various types of micrometers and their use.
6. How to properly read a micrometer.
7. How to care for a micrometer.
8. What a dial indicator is used for.
9. How to read a dial indicator.
10. The basic mechanics of a tachometer.
11. How a stroboscopic tachometer differs from a hand tachometer.
12. What is meant by torque.
13. The proper use and care of torque wrenches.
14. How to use and read thickness gages.
15. The use of valve repair equipment.

LEARNING AIDS suggested:

MODELS: NOTE: Instructor might want to bring the following tools into class to demonstrate their use.

1. Micrometers, all types
2. Rules
3. Dial indicator
4. Valve repair equipment
5. Tachometers, all types

FILM STRIPS:

(1) Hand Tool Safety (Part II) "Safety and Wrenches"
(2) Hand Tool Safety (Part III) "Safety and Detachable Socket Wrenches"

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FILM STRIPS: con'd.

NOTE: Film strips on the previous page are obtainable through H. E. I., Cleveland, Ohio. Also, record is available to run with film strips.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. How many units of measure are usually found on the mechanic's rule?
2. How would you read .333 of an inch? Explain.
3. Is 1/2 the same as .500?
4. Is 1/4 the same as .255?
5. How can you measure with a rule that has a worn end?
6. Why are there different types of micrometers?
7. How many threads does the micrometer screw have per inch?
8. What is meant by a 1 to 2 micrometer? Explain.
9. Is reading a depth micrometer the same as reading a thickness micrometer?
10. What is a vernier micrometer?
11. When would you want to use a dial indicator instead of a micrometer?
12. How would you position a dial indicator when checking for roundness of a shaft?
13. What has to be done when measuring the rpm of a four-cycle engine with a hand tachometer? Explain.
14. How is a torque wrench calibrated? Explain.
15. What is a go-no-go thickness gage?
16. What is meant by valve lapping?